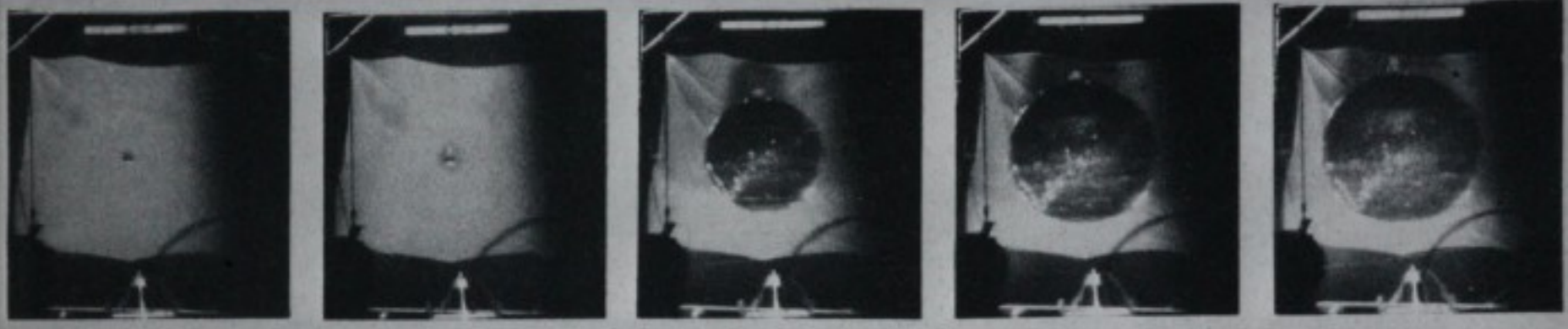
Sky and TELESCOPE



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Underwater explosion

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Radio Astronomy at Jodrell Bank — II

American Astronomers Report

Stars for March

Vol. XII, No. 5

MARCH, 1953

Whole Number 137

Sky and TELESCOPE

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WEATHER IN A DISHPAN

A few years ago, Dr. Dave Fultz, of the University of Chicago, developed a method for studying the broad features of atmospheric circulation that take place over a whole terrestrial hemisphere in the confines of a spinning "dishpan" that can be controlled at will in the laboratory. At first his experiments were limited to phenomena of a general nature, but now he has succeeded in methods to demonstrate and study on a quantitative basis such important weather phenomena as the polar front and the formation of surface circulations in association with upper-level windflow and pressure patterns. He describes his work in the December issue of the *Journal of Meteorology*, and shows photographs of dishpan experiments that bear striking resemblance to weather charts.

His first experiment of this kind is performed with a double-layer system of two homogeneous immiscible fluids (of slightly different densities) in a rotating cylindrical disk, which represents the ideal case, in frontal theory, of two completely homogeneous air masses. When the interfacial tension is reduced by suitable detergents, the lower, slightly denser layer is drawn into a domed cap centered on the "pole" by starting from a high, steady rotation of the container and reducing this rotation fairly rapidly to a constant value of 10 to 20 revolutions per minute. The wave structure that develops in the lower layer is made visible by aluminum powder resting on the interface.

Dr. Fultz describes how the eastward-moving open waves in the interface at the edge of the cap increase in wave length and develop troughs that extend obliquely in toward the center of the dome. The waves go through a process of cresting in the horizontal that strongly resembles the occlusion process so far as the boundaries and the presence of only one "cold" mass allow. He states, "The resemblance of these figures to the classical picture of the simple polar-front wave is obvious and extends to a number of still finer details that will be investigated thoroughly in the future."

In the second type of experiment, a 4- to 5-centimeter layer of water in a rotating pan is heated just under the outer edge and cooled by circulating cold water in a cylinder centered on the pole. In this way, the water in the pan is activated by a temperature difference more closely akin to that generally presumed to be operating in the atmosphere. In order to observe the relative motions at all depths of the model "atmosphere," crystals of malachite green dye are dropped in after the state of motion has become steady. The crystals mostly fall slowly to the bottom, leaving colored streaks behind them that show the motions at various levels.

Such important features as the jet stream and its association with lower-level circulations are revealed in striking detail. For instance, Dr. Fultz says, "The pattern of motion obtained when the Rossby number is low consists, at the top surface, mainly of a narrow westerly jet. Steady trains of sinusoidal waves occur in this jet, which is continuous around the annular ring [of the dishpan] with anywhere from two to six waves of varying shapes, depending on the exact circumstances. (These waves progress toward the east at around 10 to 15 deg. long per revolution, *i.e.*, per 'day.' . . .) Underneath and slightly to the east of each trough in the upper jet there is a surface cyclone that usually gives the impression of occluded-type structure."

In their studies of various factors in atmospheric seeing, astronomers are becoming increasingly concerned with the jet stream and other features of atmospheric circulation; thus, they have a special interest in these dishpan experiments. It seems possible, also, that models of this kind may eventually be developed to simulate the atmospheric phenomena of the sun and other celestial bodies. The second arrangement used by Dr. Fultz is similar to one used earlier by R. Hide, of Cambridge University, in some convection experiments concerned with motions in the earth's core.

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COVER: A motion picture record of bubble motion from an 0.55-pound tetryl charge detonated 300 feet below the water surface, showing the pulsations of the gas products. The times indicated are in milliseconds after the detonation. The cycle of the pulsations is in some ways analogous to the changes in Cepheid variable stars. From "Underwater Explosions," by Robert H. Cole, with permission of the Princeton University Press. (See page 119.)

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BACK COVER: The total solar eclipse of February 25, 1952, taken on the Naval Research Laboratory expedition, by Hagen and Hawkins. The three prints are from a single exposure of 1.5 seconds on Panatomic X emulsion, using the Gardner camera at an aperture of eight inches and a focal length of 18 feet. The top picture shows the corona; the one at left below was printed to show underlying detail; the picture at right below was printed still more heavily to show the structure in the corona above the prominences. North is at the bottom and west on the left. Naval Research Laboratory photograph.

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PULSATING STARS

BY OTTO STRUVE, *Leuschner Observatory*
University of California

DURING the night of June 5-6, 1947, the two largest telescopes then in existence were simultaneously trained upon the same 7½-magnitude star in the constellation Lyra. The two spectrographic observers had not consulted with one another beforehand, and the coincidence was, in part, due to pure chance.*

If the star had been one chosen at random from among the 10,000 or so stars of the same magnitude or brighter, the mathematical probability of this happening would be about one in 100 million. Since the average spectrographic observer obtains, in his lifetime, approximately 10,000 photographic exposures of stellar spectra, the chances of such a coincidence happening to any single person are negligibly small: 10,000/100,000,000.

But the particular star observed on the night of June 5-6 was not one picked at random. It was the cluster-type variable RR Lyrae, and our interest in it far exceeds that attached to a random member of the Milky Way's stellar population. In fact, if we like, we can regard mathematically the importance of RR Lyrae, in comparison to an average 7.5-magnitude star, as the ratio of the two numbers: one in 10,000 to one in 100,000,000!

Was this 10,000 times greater importance justified by results obtained on that particular night? Most astronomers would agree that it was. For it was from the study of the spectrograms obtained on June 5-6, 1947, that a new phenomenon in the atmospheres of pulsating variable stars was discovered. We refer to this phenomenon as the discontinuity of the velocity curve.

The concept of discontinuity is one that astronomers are not very familiar with, and it came as a surprise that the velocity curve of a variable star should be discontinuous. The light of RR Lyrae varies smoothly between magnitudes 7.1 and 8.0, in a period of slightly longer than one-half day. Hence, it was thought that the radial velocity should also vary smoothly, as indeed earlier representations of the velocity curve had suggested it might do.

However, the observations made in 1947 left no doubt that these earlier representations were inaccurate in one narrow region of each cycle.

Of special interest is the behavior of the hydrogen absorption lines. When the star is bright, these lines are strong and broad, resembling the spectral lines of a 10,000° star, like Vega. The displacements of the lines show that the atmosphere of RR Lyrae in this stage is rapidly expanding; the gases move outward, and produce, as seen from the earth, a Doppler shift toward the violet side of the spectrum.

As the light decreases, the hydrogen lines become narrower and weaker. The expanding atmosphere gets cooler, reaching a temperature of about 7,000°, and its pressure decreases as it occupies higher and higher levels above the photosphere. Gradually the outward motion of expansion is checked by gravity, and the overexpanded star begins to contract.

We expect to see this contraction continue until the infalling gases have overshot their normal level, and have produced in the star an excess of gas pressure that works against gravity, and which once again causes the gases to reverse their motion. Instead, the sharp hydrogen lines become rapidly weaker, and disappear at a stage when they still record contraction rather than expansion.

But before these lines have faded away, the spectrum already reveals a set of new absorption lines of hydrogen, excessively broad and hazy as though they were produced in the deepest layers of the atmosphere of RR Lyrae. These lines are shifted to the violet and record the outward, expanding motion of a deeper layer, coexisting with the upper contracting layer. Clearly, the two layers must collide, and the relative velocity of one stratum with reference to the other is of the order of 100 kilometers per second, as shown in Fig. 1.

Imagine the violence of the storm that is caused by this collision of two gas masses. In RR Lyrae the visible result of this storm is the appearance of narrow emission lines of hydrogen. Aerodynamical experts, working with powerful wind tunnels, have actually produced emission phenomena of a similar kind when a powerful shock wave in hydrogen is focused in a tiny spot within the tunnel by means of a suitable conical diaphragm.

At Mount Wilson, R. F. Sanford succeeded in showing that the same discontinuity exists in the radial velocities of the Cepheid variable W Virginis, whose period is 17.3 days. The latest contribution to the study of this remarkable phenomenon comes from Arthur Abt, who found a great many metallic lines double in W Virginis and succeeded in determining the temperatures of the two opposing layers. It turned out that the deeper expanding layer is 800° to 1,000° hotter than the outer, contracting layer.

Both RR Lyrae, a cluster-type variable, and W Virginis, a peculiar Cepheid variable, belong to Population II of our Milky Way system. The suspicion therefore exists that the discontinuity in the velocity curve may be present only among the members of this relatively rare group, in the vicinity of the sun. But it is also possible that ordinary, Population I Cepheids fail to show the discontinuity because the component

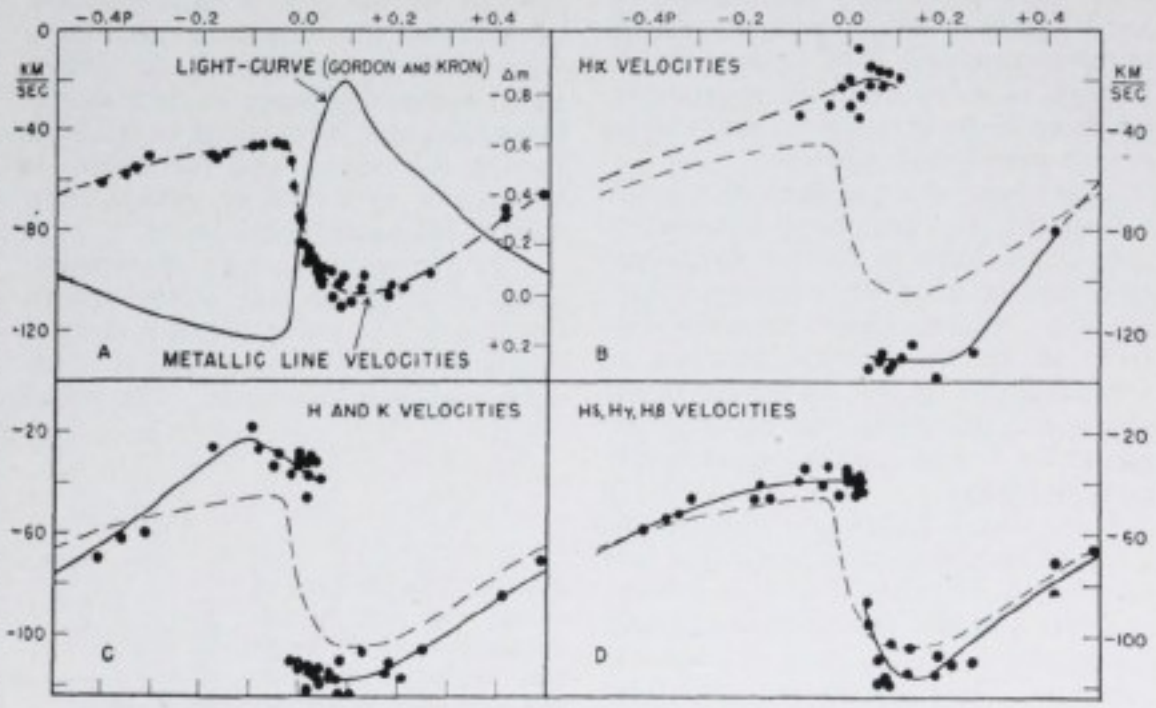


Fig. 1. Velocity curves and light curve of RR Lyrae. The faint metallic lines do not show the discontinuity effect; their velocity curve (A) is repeated as a broken line in B, C, and D. For hydrogen and calcium, the breaks in the velocity curves of B, C, and D indicate the simultaneous presence of two layers in the star's atmosphere. From an article by R. F. Sanford in the "Astrophysical Journal," Vol. 109, 1949.

*The telescopes were the 100-inch reflector on Mount Wilson with R. F. Sanford observing, and the 82-inch reflector of the McDonald Observatory with Dr. Struve as the observer. —ED.

lines are never sufficiently resolved. Thus, even in RR Lyrae only a few lines show the effect, yet no one would claim that the metallic lines in this star originate in still another, continuously oscillating layer.

If we should find that the phenomenon is not a freak occurrence but that it exists in all pulsating stars, the effect would be tremendous in our understanding of the mechanism of pulsation.

Ever since the time when F. R. Moulton, H. C. Plummer, and H. Shapley discarded the early hypothesis of binary motion, as applied to such stars as Delta Cephei and Eta Aquilae, astronomers have followed in the footsteps of A. Ritter, R. Emden, A. S. Eddington, S. Rosseland, P. Ledoux, and others, in regarding these Cepheid variables as periodically expanding and contracting gas spheres. We refer to these changes as pulsations of constant form, but of variable mean density. Every element within the star vibrates back and forth, along the radius, and in phase with all other elements.

This type of pulsation differs radically from the kind that involves changes in shape, with a constant volume. The latter were investigated by Lord Kelvin in 1863, and apply strictly to noncompressible fluids — as in the vibrations of a balloon filled with water, which oscillates between the shape of an orange and that of a lemon.

I have been trying to think of a simple experiment or terrestrial observation that would serve to illustrate in a concrete manner what we mean by a pulsating star. Analogies based upon the similarity of the mathematical equations of a vibrating string and an oscillating gas sphere are sufficiently convincing to the expert but fail to impress the nonmathematical reader.

It is natural, perhaps, to think first of a toy balloon, inflated with air and subjected to a disturbance, such as a blow, or better a sudden release from a greatly compressed but spherically symmetrical condition. But we do not, in actual experience, observe oscillating toy balloons, and a little reflection will reveal the reason. The membrane, when tight enough to oscillate at all, resembles the head of a drum (although no drum I have ever seen was airtight), and its oscillations should be so fast and so small in amplitude as to escape the human eye. These oscillations would more nearly illustrate the subject of acoustics than of Cepheid variables.

A much better illustration, suggested to me by L. G. Henyey, is provided by the gaseous bubbles which result from underwater explosions. The front cover shows a series of motion picture photographs obtained at intervals of approximately five milliseconds (5/1,000 of a second). The charge was a one-half pound pellet of tetryl, which is the trade name of a more sensitive explosive than TNT, and has the chemical name of trinitrophenylmethylnitramine ($C_7H_5O_8N_5$). The explosion took place at a depth of 300 feet below the water surface, and the gaseous bubble was recorded as a dark, roughly spherical feature, seen against the white background of a screen illuminated by flashbulbs. The first three frames show the rapid initial increase in the size of the bubble. This growth is accompanied by a radial pushing away of the water, which is not seen in the photographs. The water acquires inertia, and its outward motion continues beyond the stage where the pressure of the gas is hydrostatically balanced by the weight of the water. After about 15 milliseconds, the diameter of the bubble begins to decrease because the water is beginning to fall back toward the center, and the bubble is compressed to a density greater than that of hydrostatic equilibrium.

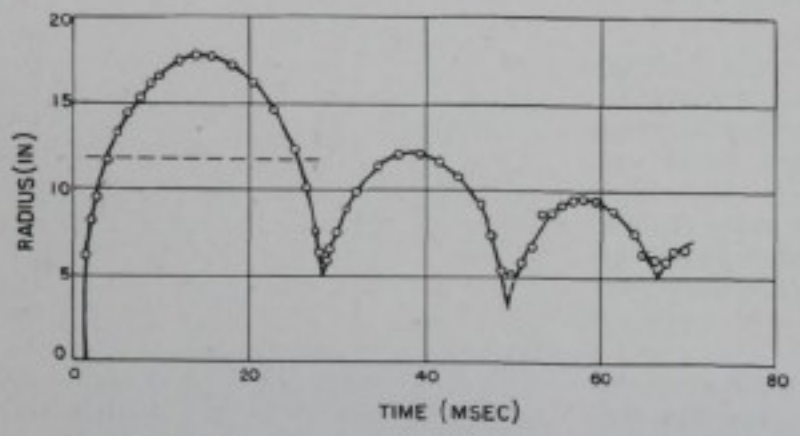


Fig. 2. Oscillations in the radius of the gas sphere from the charge exploded 300 feet below the surface, pictured on the front cover. This and Figs. 3 and 4 are reproduced from the book, "Underwater Explosions," by Robert H. Cole, published by the Princeton University Press, 1948.

Fig. 2 presents a series of measurements of the bubble radii, plotted against the time. The curve shows a damped oscillation with an average period in the vicinity of 25 milliseconds. The period gradually decreases, as the bubble rises relatively slowly to the surface.

When different charges are exploded at the same depth, the period of the oscillation increases with the charge. When the same charge is exploded at different depths, the period increases with decreasing depth. These results are illustrated in Fig. 3. A direct comparison of the bubble sizes in a single explosion is given in Fig. 4.

The theory of hydrodynamics provides an explanation for these observations. Qualitatively, we may say that the power of the charge forces the water to move farther outside the equilibrium diameter of the bubble, causing the period to increase roughly as the cube root of the weight of the charge. On the other hand, greater depth means greater pressure of the water and, consequently, greater resistance to the push of the expanding bubble. Hence, the period is very nearly inversely proportional to the depth of the explosion.

In the case of a Cepheid variable, the gas sphere is suspended in the almost perfect vacuum of interstellar space. Hence, there are no exterior masses to be pushed aside. But in the place of inertia of these masses the gas sphere is activated by its own gravity. If the gas is at first compressed and then begins to expand, it is sure to overshoot the place where gravity is exactly balanced by the pressure inside the gas. After a while, the overextended sphere once more starts to contract, and again the momentum of its own motion causes it to contract to a greater degree of compression than is consistent with equilibrium conditions.

Very simple considerations, analogous to those that led to the dependence of the explosive bubble's period on weight of charge and depth below the water surface, show that the period of an expanding and contracting star is inversely proportional to the square root of its mean density.

For a star with the mean density of the sun (about 1.4 times that of water) the period would be of the order of two hours. For a giant star, such as Delta Cephei, the mean density is about 4/10,000 that of the sun; the square root of this number is 2/100. Conse-

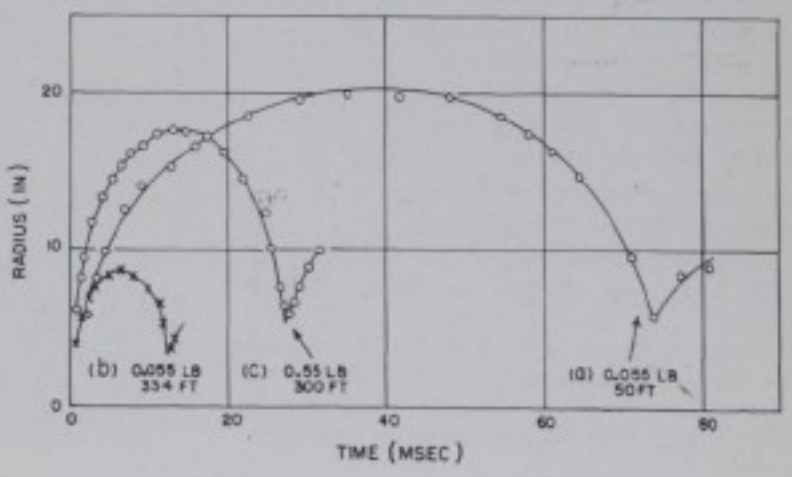


Fig. 3. The changes of radius with time for tetryl charges of the same size exploded at different distances below the surface of the water.

quently, the period of pulsation should be approximately 2 hours × 100/2 = 100 hours, or more than four days. Actually, the period of Delta Cephei is 5.37 days.

As we have already seen, the spectrographic observations of Cepheids and cluster-type variables do not give us the radii of these stars and their changes within each cycle. What we measure is the *velocity* of expansion and contraction.

But by means of a simple computation we can convert the radial velocities into the corresponding changes of the radius. It is as though we know at each moment the speed of a plane, and compute from the total elapsed time the distance it has traveled. Assuming that the velocity curve is continuous, or at least that we can substitute for the discontinuity a smooth curve, we obtain at the bottom of Fig. 5 the change in radius, ΔR, which is directly comparable to the measures of the explosion bubble in Figs. 2 and 3. The two curves resemble one another — both have broad, flat maxima, and narrow, almost pointed minima. The radius of the star itself may be inferred from its intrinsic brightness (read off the period-luminosity curve) and its temperature as given by the spectral type. Thus, a recent discussion by J. Stebbins gives for the radius of Delta Cephei 53 times the radius of the sun, or nearly 40 million kilometers. The change in radius amounts to only three million kilometers (Fig. 5), or about eight per cent.

The discovery of the discontinuity in the radial velocity introduces a new element into the discussion. It shows, first of all, that in the outermost regions of a pulsating star the individual elements of the gas do not vibrate in phase: some are still contracting, while others are already expanding. This makes it necessary to modify the theory. Fortunately, such a modification was already advanced in 1938 by M. Schwarzschild, in order to account for another discrepancy between the classical theory of Eddington and the observations. We shall not now attempt to explain this discrepancy. It concerns the respective phases of the light curve and the velocity curve, and it has, for many years, stood as an obstacle in the way of the Eddington theory.

Schwarzschild suggested that in the deep interior of a star the pulsations are essentially as described in the theory of the simultaneous (in-phase) vibrations of the gaseous elements. But in the outermost regions of the star the elements need not all vibrate in unison. We can perhaps think of water beating against a vertical wall as representing the type of standing waves in which the waves are not traveling over the surface of the sea because the incoming wave interferes with the reflected wave. The

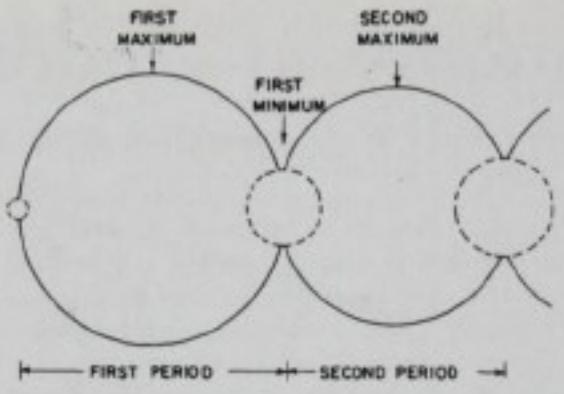


Fig. 4. Pulsations of the gas products from an underwater explosion.

result is an up-and-down motion only, without the horizontal shift that makes it possible for enthusiastic swimmers to travel long distances on their surfboards when the beach is gradual and not abrupt.

Thus, in the star the "standing" waves of the interior, which are the only ones that appear in the Eddington theory, arise from an imperfect reflection at the outer surface of the star. The "traveling" wave is what we really observe, and each wave requires time to travel outward, until its trend is reversed. Finally, the wave begins to flow back, and in doing so it may experience a collision with the next outward-bound wave.

There is nothing comparable to this in the exploding bubble, and we must be satisfied with the very imperfect analogy of an ocean wave.

Still, we can see that by measuring the interval between greatest outflow and greatest return flow of a single wave on the beach, we do not necessarily

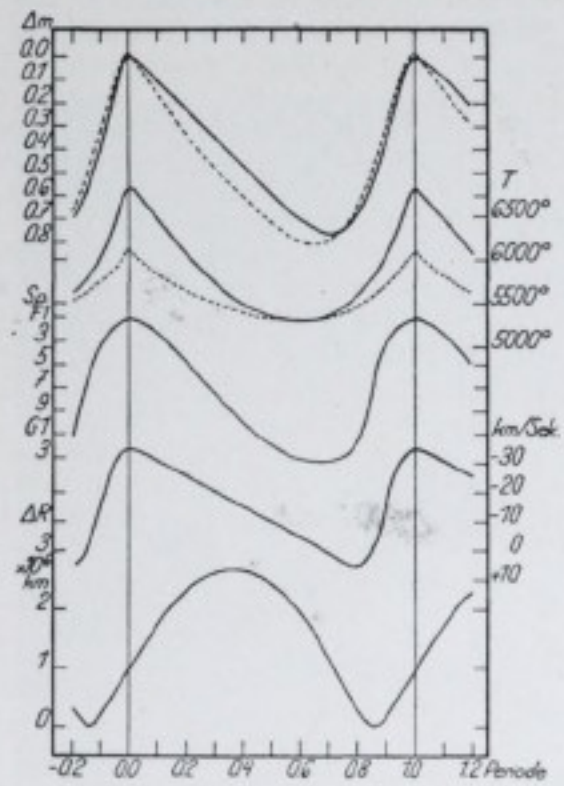


Fig. 5. The characteristics of the changes in Delta Cephei, reproduced from "Sterne und Sternsysteme," by W. Becker, Dresden and Leipzig, 1950. From top to bottom are the light curve, temperature curve, spectral changes, radial velocity curve, and radius changes.

obtain one half the period of the pattern of standing waves in the interior. Thus, Abt, in his work on W Virginis, has suggested that the displacement curve of ΔR (as at the bottom of Fig. 5) obtained from his radial velocities "shows an overlap of cycles such that when the upper part of the atmosphere is contracting the lower is expanding." The curve even suggests "that the true period of pulsation is twice the period of light variation and the time between pulses is just one-half the duration of the pulse."

It is as though we wanted to find the period of a single wave thrown up on a shallow beach: The water rushes forward, then retracts; but before it has had time to flow back more than halfway a new, powerful wave arrives from the vast reservoir of the sea, overcoming the receding wave and rushing forward to form a second maximum outflow after one half the interval of time required for the original wave to complete its cycle.

Is it necessary for such a numerical relation as 1:2 to hold in all cases? Probably not, for we can infer from the analogy with the wave on a beach that its own period depends upon the character of the beach, its inclination to the horizontal plane, its smoothness, and so on. There would not necessarily be any simple relation between its duration and the period of the standing waves in the deeper parts of the ocean.

An important aspect of the study of pulsations concerns the energy that is needed to maintain the periodic expansions and contractions of a gas sphere. In the older theories, which were concerned only with standing waves, the motions of expansion and subsequent contraction would be maintained indefinitely if there were no friction inside the gas. As is apparent from the underwater bubble, the pulsations gradually die down, and in the stars a similar effect of damping must occur. However, as Eddington and other later theoreticians have shown, this type of dissipation in a star is quite slow, and there would be no appreciable diminution in the amplitude of a pulsating variable during the intervals of time covered by modern observations.

A much more rapid dissipation of energy must be expected when the waves project outward and disappear in space, as do the waves on a shallow beach. We can think of an analogous situation if we imagine a large swimming pool with vertical walls. Suppose the water is agitated in such a way as to produce a pattern of standing waves of the kind that allows a floating cork to move up and down but not appreciably sideways. This pattern of waves will persist for a considerable length of time, with the up-and-down motion slowly decreasing in

(Continued on page 124)

Radio Astronomy at Jodrell Bank--II

By A. C. B. Lovell, *Jodrell Bank Experimental Station, University of Manchester*

LAST MONTH'S article described some of the work now in progress at Jodrell Bank on the galactic and extragalactic radio emissions. Nearly one third of the effort at the experimental station is on the radio echo techniques for the study of the astronomy and physics of meteors, and some account of this work will be given in this second article.

When a meteor enters the earth's atmosphere it evaporates at an altitude of about 100 kilometers, and its energy is dissipated in light, heat, and ionization. About a thousandth part of its energy is transferred to ionization in the form of a thin column several kilometers in length. The reflection of radio waves from these columns of ionized material can readily be observed on conventional pulsed radar equipments as a transient echo, and by this means the incidence of meteors in the atmosphere can be studied under any conditions of cloud or daylight. The number of meteors detected in this manner depends on the characteristics of the radio equipment, particularly on the size of the aerial, wave length, transmitter power, and receiver sensitivity.

With contemporary techniques, it is quite feasible to detect meteors which are several magnitudes fainter than those observed by the human eye under clear dark sky conditions. Although the ability to observe meteors in this manner under any sky conditions is of great value, it is necessary to find the orbits of the meteors before any serious contributions can be made to meteor astronomy. This demands, particularly, the measurement of the radiant position and of the velocity of the meteor. Some of the first radio solutions to these problems were devised at Jodrell Bank, and as they are still in regular use a brief description may be of interest.

Radio echo measurements of meteor radiants and velocities. The method of radiant determination, which was originally devised by J. A. Clegg, depends fundamentally on the specular reflecting properties of meteor trails. Except in the case of occasional densely ionizing meteors, it is found that the main radio reflection from the meteor trail is obtained only when the perpendicular from the radio station to the trail lies within the aerial beam. Hence, if a radio equipment with a narrow aerial beam is in use to study the meteors of a shower from a particular radiant, records will be obtained only when the beam is positioned 90 degrees from the radiant.

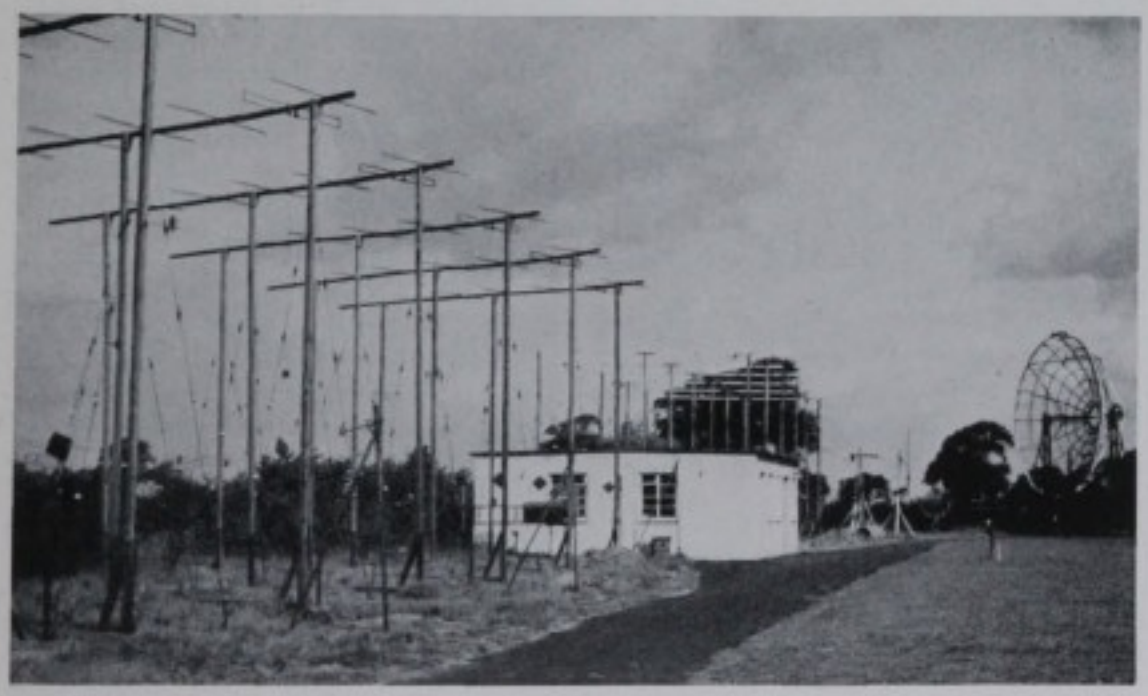
Evidently, for a narrow beam fixed in an easterly or westerly direction, echoes from a given radiant can only be obtained at transit of the radiant and so its right ascension can be determined directly. If the beam is now moved through an angle θ in advance of the radiant, the time taken for the radiant to move through θ can be found and hence its declination.

In the standard form of the equipment now in use at Jodrell Bank, two aerial systems, inclined 25 degrees north and south of west and directed at low elevation, are fed from a common transmitter, and the radio echoes from meteors in each aerial are photographed continuously on a moving film. The results are analyzed in terms of range-time plots; the accompanying illustrations show the effect during an active shower. The radiant position of the shower can be calculated from the envelope of the range-time diagram.

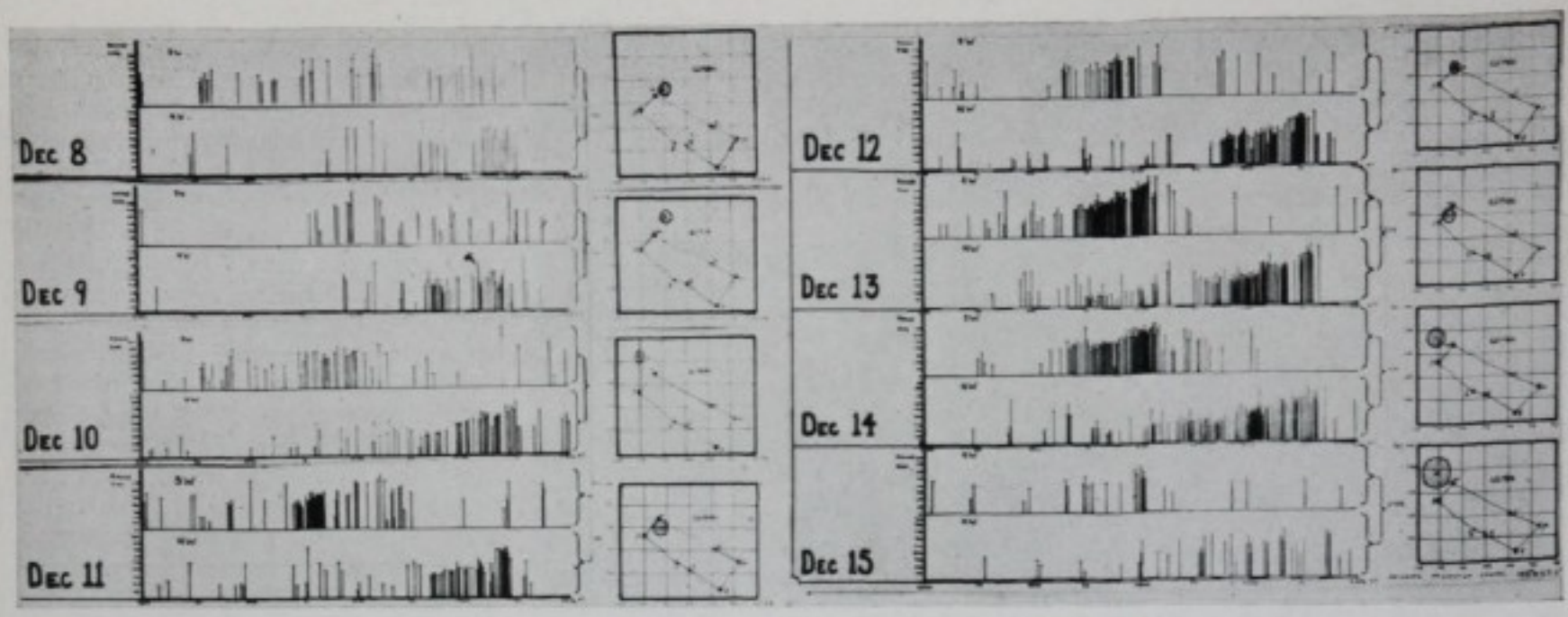
A recent event of topical interest concerns the Giacobinid shower during the afternoon of October 9, 1952. The tremendous visible meteor shower which occurred in October, 1946, when the earth crossed the orbit of the Giacobini-Zinner comet only 15 days behind the comet is still a vivid memory to many observers. In the succeeding years, the earth has crossed the orbit at a great distance from the comet and no shower has been observed. Last October the earth was due to cross the orbit half a year in advance of the comet, and in view of the close packing of the debris near the comet no shower was expected. Nevertheless, during daylight in the afternoon of October 9th, a very strong shower was observed on the radio equipment with an equivalent visual hourly rate of about 200. The duration was very short, the entire shower lasting only about two hours. Some of the Jodrell Bank records are reproduced here; the observed radiant position agrees well with the predicted value.

The velocities of meteors in the earth's atmosphere cover a range up to 72 kilometers per second, and the accurate determination of these velocities has always presented very severe difficulties. The first radio echo measurements of velocities were made in England during the Giacobinid shower of 1946 by Hey and his colleagues, who observed the change in range with time of the echo reflected from the ionization near the head of a few very densely ionizing meteors. Shortly afterward, Davies and Ellyett at Jodrell Bank succeeded in photographing the radio diffraction pattern as the meteor crossed the perpendicular point from the station to the trail.

The maxima and minima in the scattered signal are due to the passage of the meteor through successive Fresnel zones; it can be shown that the case is strictly analogous to the diffraction of light at a straight edge. Thus the di-



The aerial system used for the continuous meteor survey at Jodrell Bank. These arrays produce narrow beams at low elevation, the one in the foreground being directed 25 degrees north of west, the one beyond the hut 25 degrees south of west. The radio echoes from the aerials are recorded separately on a moving film, and the radiant co-ordinates of showers can be calculated from the range-time plots. At the extreme right can be seen the 30-foot steerable radio telescope.



An example of range-time plots given by the continuous meteor survey equipment for the Geminid shower. The right ascension and declination of the radiant can be calculated from the records, and its position is shown on the constellation chart at the right for each day. The over-all curve of activity for the shower can also be obtained.

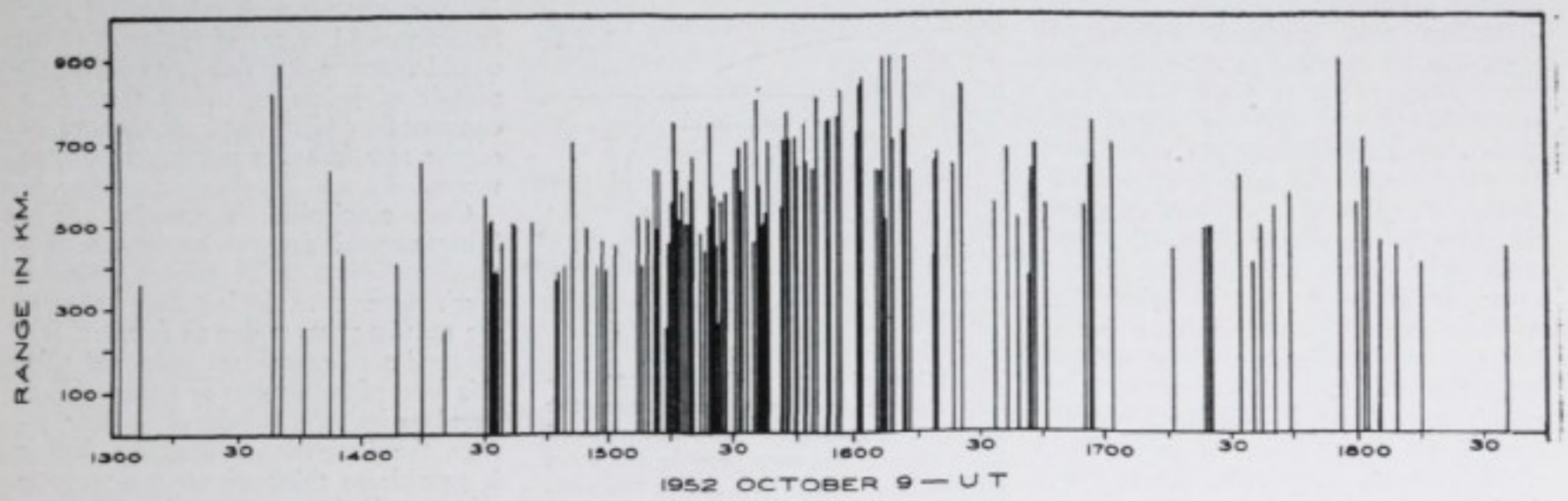
mensions of the zone pattern are known, and the time of passage of the meteor is obtained from the photographic record of the cathode ray tube as shown in the illustration on page 124. In the Jodrell Bank technique, pulsed signals are used, and the range is measured as in conventional radar methods. Subsequently these amplitude-time methods of velocity measurement were developed by McKinley in Canada using continuous wave signals, in which case a separate pulsed transmitter is required for range measurement. McKinley's extensive work on the velocity measurements has already been described in *Sky and Telescope* (December, 1951).

The summer daytime meteor streams. After the observation of the great Giacobinid meteor shower in October, 1946, the workers at Jodrell Bank commenced a systematic survey of the meteoric activity by day and night, with an apparatus in which the rate of occurrence of echoes was closely related to the number of meteors seen by a visual observer under good conditions.

No unexpected features were observed until the advent of the Eta Aquarid meteor shower in early May, 1947. This shower transits at dawn, and the continuation of the radio echo observations into the daytime sky showed that the Eta Aquarid shower was not an isolated event but merely the beginning of a great belt of meteoric activity. This activity steadily increased and by mid-June reached unprecedented strength. Throughout July it declined, and by the end of the month the well-known Delta Aquarid and Perseid showers were the dominant features of the meteoric activity. Measurements of the radiant positions in 1947 showed that this summer daytime activity was comprised of a number of very active meteor showers, closely grouped in right ascension and declination along the ecliptic. However, several years elapsed before combined measurements of the velocities and radiants enabled the picture to be clarified.

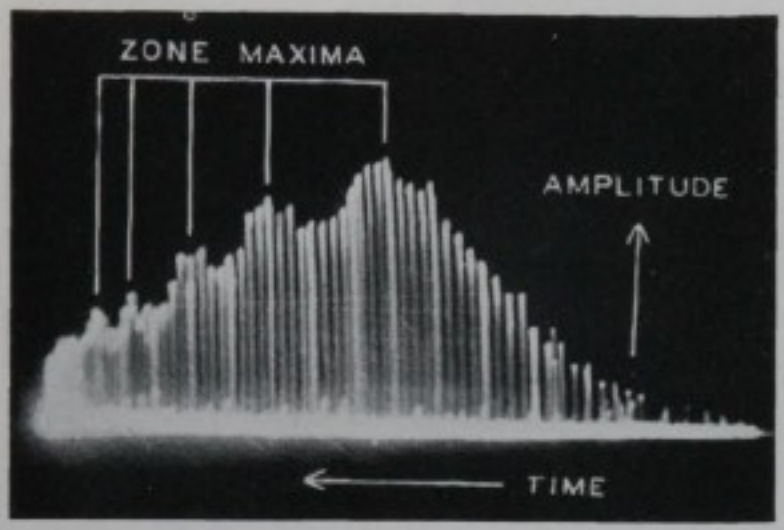
It is now well established that this daytime activity consists of a number of showers moving in orbits of unusually short period. The dominant shower of the sequence is the Arietids, active throughout June; and the exceedingly high rate of meteors during that month is enhanced by the presence of another rich shower — the Zeta Perseids. The combined rate in mid-June exceeds by three times that of the well-known Geminid shower of December. The orbits of some of the principal daytime streams are shown on page 124; it will be apparent that they are unique in comparison with cometary orbits. The only relation so far established is that the Beta Taurids of late June and early July move in the orbit of Encke's comet.

This stream is of particular interest; its inclination to the ecliptic is small, and the earth intercepts the orbit again in the autumn months, giving rise to the nighttime Taurid shower. The discovery of the June Beta Taurid shower fulfills a remarkable prediction made by Whipple in 1940 when, from his photographic studies of the autumn Taurid shower, he derived the orbit and predicted that the second intersection with the earth should give rise to a shower



The range-time plots for the return of the meteor shower associated with the Giacobini-Zinner comet. The activity was confined to daylight hours, and it is possible that this is the only existing record of the return of the shower.

in the summer daytime. All that can be said at present about the other orbits is that they bear more similarity to the orbits of asteroids and minor planets than to comets.



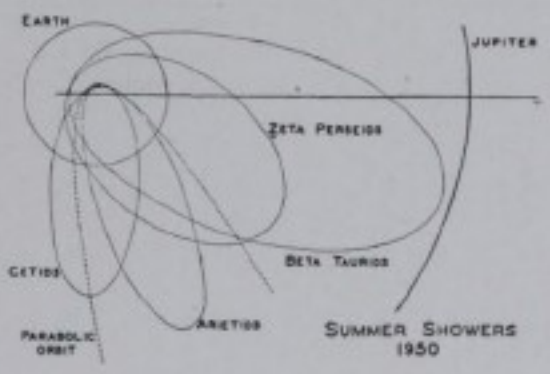
The diffraction pattern of the radio waves reflected from a meteor trail as it crosses the aerial beam. Each pulse represents a time interval of 1/600 second. The range is measured on a separate display; from this and the wave length the velocity of the meteor can be calculated. The decay of the echo amplitude is here caused by the diffusion of the electron column.

The interstellar meteor problem. Although there has always been a good measure of agreement that shower meteors move in closed orbits in the solar system, the problem of the sporadic meteor orbits has led to a wide divergence of views. The fireball catalogue of von Niessl and Hoffmeister assembled apparently strong evidence that fireballs were moving in hyperbolic orbits with an origin in interstellar space. Later, Hoffmeister's statistical studies of the diurnal and seasonal variation in sporadic meteor rates also appeared to show that a large fraction of sporadic meteors were of interstellar origin. Then, after 1930, the velocity measurements of Opik, using a rocking mirror during the Arizona expedition, and later in Estonia, seemed to confirm that over 60 per cent of the sporadic meteors were moving with velocities in excess of the parabolic limit. On the other hand, the analysis of the visual data by Porter failed to indicate the existence of these high velocities, and he expressed strong criticism of Opik's results. The accurate photographic measurements of Whipple also failed to show any significant hyperbolic velocities.

Against this confused background great interest attached to the radio echo investigation of the problem, which was approached from different angles by McKinley and Millman in Canada and by Davies and the writer at Jodrell Bank. The Canadian workers sampled the sporadic distribution from all directions, whereas at Jodrell Bank directional aerials were used to select the sporadic meteors whose radiants were between two small-circle planes enclosing either the apex or antapex of the earth's way. The Jodrell Bank results were eventually extended to meteors of the 8th or 9th magnitude, but no evidence was found for an interstellar component exceeding one per cent of the total sporadic distribution. The Canadian results are similar, and hence the radio work supports the view of those who believe in the solar system origin for all meteors — both shower and sporadic.

Problems in meteor physics. Simultaneously with the work in meteor astronomy, a good deal of progress has been made in the radio echo studies of the physical processes occurring when the meteor evaporates. Thus from the observation of the amplitude and durations of the radio echoes from the trails, it is possible to calculate the electron density. Comparisons with the observed visual magnitudes of individual meteors may be used to investigate the luminous and ionizing efficiencies during the evaporation process.

Radio echo methods are also in use for measuring the heights of the trails, leading to information about the diffusion rates and the processes by which the ionized material disappears. Many of the echoes from densely ionizing meteors are of long duration and show pronounced fluctuations in amplitude during their lifetimes. These are caused by the disruption of the electron trail into segments under the influence of the turbulent conditions in the high atmosphere. These segments may become oriented to scatter back a strong signal, and their relative motions can be measured by the interference pattern produced at the receiver. At the same time the whole trail often shows a pronounced drift in range, giving a measure of the translational winds.



The orbits of some of the summer daytime meteor streams projected onto the plane of the ecliptic. The Arietid and Zeta Perseid showers provide the most striking meteoric events during the year. The Beta Taurid shower of late June or early July moves in the orbit of Encke's comet.

Other work at Jodrell Bank is concerned with the radio echo studies of the aurora borealis. These results are correlated with the radio star fluctuation phenomena described previously, and with solar and magnetic observations. Nearly all this work will benefit greatly when it becomes possible to use the new 250-foot radio telescope although, as mentioned in the first article, this new instrument will be applied first to the study of the radio emissions from space.

OPTICAL SOCIETY MEETING

The spring meeting of the Optical Society of America will be held in New York City, at the Hotel Statler, on March 19-21. There will be a group of invited papers, as well as the usual contributed presentations. Any interested persons may attend, and may request copies of the program from Dr. Arthur C. Hardy, Secretary, Optical Society of America, Massachusetts Institute of Technology, Cambridge 39, Mass.

Hotel reservations should be made directly with the Hotel Statler, 7th Ave. and 33rd St., New York 1, N. Y., mentioning the Optical Society of America.

PULSATING STARS

(Continued from page 121)

amplitude because of the friction of the water with the bottom, the vertical walls, and with itself. Now suppose that one of the sides of the pool is replaced by a shallow beach-like surface whose level is that of the undisturbed water surface. The waves then spill over this flat surface, and the whole volume of water will come to rest much more rapidly than it does in the case of the pool with all walls vertical. The dissipation of energy in this latter case is thus seen to be much more rapid than in the former. Similarly, in the Schwarzschild type of pulsations we would expect a fast decrease of the amplitude of pulsation, unless there is a constant flow of energy from the interior of the star into the mechanism of the waves.

One conclusion is certain. The Schwarzschild process involves a continuous dissipation of energy which is much larger than the loss that occurs in the standing waves due to friction. But we need not be too much concerned with this form of energy loss by a star. Compared to its total supply of nuclear energy, the dissipation is minute. And it is possible to think of various ways in which radiative energy might be converted into energy of motion that could be subject to dissipation.

LETTERS

Sir:

In an age of high-altitude rocket flights, photographs showing the earth's curvature have become rather common. Nevertheless, this picture of a hull-down ore boat we believe represents not only one of the few photographs of hull-down ships in existence, but also one of the best—in spite of its poor quality.

It was taken with the Dearborn Observatory 18½-inch refractor, using a 10-inch objective diaphragm, Eastman IIG emulsion, and an exposure of about half a second. The observatory is ideally situated for obtaining such photographs, having a clear view of the Lake Michigan horizon to the east. However, in spite of the use of a yellow filter and an objective diaphragm, haze and bad seeing make opportunities for taking such pictures rather rare, and this is the best result of numerous attempts during the summer and autumn of 1952.

From left to right are the after-deckhouse, stack, and pilot house and bow. The top part of the bow is white, evidently a painting scheme used for a particular company's boats. Hence the white pilot house is not easily distinguished from the bow, which is not entirely below the horizon, as it is considerably higher than the midship section.

The height of the horizontal optical axis of the telescope above the lake level is about 56 feet, making the distance of the horizon from the instrument some 9.3 miles. If the ship had 13 feet of freeboard amidships, fairly typical for such ships when loaded, its distance was about 14 miles or, of course, more. The apparent visible length of the ship was a little more than 27 minutes of arc, and its computed length across the line of sight was about 570 feet. Overall lengths of 600 feet for such ships are quite common.

C. B. STEPHENSON and
R. A. WOELFFER
Dearborn Observatory

A ship hull-down on Lake Michigan, as seen through the Dearborn 18½-inch refractor. The enlargement is about 1-1/3 times from a contact print. Dearborn Observatory photograph.

Sir:

On the morning of June 28, 1952, I was a passenger in a United Airlines DC-6 flight en route from Omaha to Denver. About 3:30 a.m., I awakened from a slumber, and scanned the sky toward the east. I detected a silvery-white cloud that was long, thin, and strangely shaped, with one straight part, one portion that curved completely back upon itself, and one portion that was slightly diffused; the cloud exhibited three well-defined and separate segments.

The remarkable trail in the sky, I felt quite sure, was the dust cloud from a meteor, disturbed by high-level winds, and at great enough height so that it was already illuminated by the morning sun, even though at our altitude of 12,000 feet above sea level the sky was still dark. I watched the trail until about 4:10 a.m., when our plane was only about 1,000 feet above the ground, approaching the Denver airport, and morning twilight had set in.

To check whether the trail was from a meteor, I spoke to the plane's pilot, Capt. Park R. Learned. Not only did he confirm my surmise, but he told me that it was the most brilliant fireball he had seen in his whole flying career. Moreover, several other pilots had seen the object. They had noted that it increased in brightness as it moved, that it attained an intense greenish white color, and that it illuminated the landscape at maximum more brightly than does the full moon.

The pilots had exchanged information by radio with other planes in the vicinity; their rough triangulation placed the terminal flash near the Nebraska-South Dakota border, somewhere east of Valentine, Neb. It was seen by one pilot who was west of Cheyenne, Wyo., and by another who was practically over Des Moines, Iowa.

I later corresponded about it with Captains E. B. Gray and Charles Blades, both of whom had observed the meteor. Capt. Gray stated that it was the brightest in his flying experience of over 26 years. The time of occurrence, within a minute or two, was 2:45 a.m. MST. Thus, the trail was still visible at least an hour and 25 minutes after the meteor.

Unfortunately, I could not find a camera on the plane, and I was thus unable to photograph the brilliant trail. But at least I did have the opportunity to observe what is described by Watson in **Between the Planets** as "among the rarest of meteoric phenomena."

WALTER ORR ROBERTS
Boulder, Colo.

Sir:

I used an old radio cabinet to show off the transparency of the Mare Imbrium region of the moon that was included as an insert in the January **Sky and Telescope**. I backed the picture with two sheets (one layer) of typing paper. This gave it a yellow color, making it look natural. A 60-watt lamp was placed inside the cabinet, with a 12 x 14-inch piece of glass in front of the transparency, and bright tin as a reflector behind the bulb at the rear. As I read Mr. Copeland's article, I could pick out the craters and other features with a 6x finder scope.

CHESTER E. OTT
Norwalk, Wis.

ASTRONOMY AND METEOROLOGY

Several papers of astronomical interest were presented at the meeting of the American Meteorological Society in New York, January 26-29. One of the 10 scientific sessions was devoted to the atmospheres of the planets and two to solar-weather relationships. The second of these was a panel discussion in which several astronomers took part.

Among the papers was one by Jean I. F. King, Air Force Cambridge Research Center, on the thermal structure of the atmosphere of Mars. The large concentration of carbon dioxide in contrast to the minute quantity of water vapor was found to cause the 10-micron band of carbon dioxide to be the controlling factor in the infrared heat transfer in the Martian atmosphere. Preliminary calculations indicate that even for maximum solar heating the zone of convection is confined to the lowest three kilometers of the planet's atmosphere.

Dr. Donald H. Menzel, Harvard Observatory, spoke about variations in solar radiation and their bearing on the earth's atmosphere. He pleaded for further studies of the statistical relations between auroral activity and terrestrial weather patterns. Dr. Joseph Kaplan and Hilda Kallman, University of California at Los Angeles, have studied the absorption of photon radiation by oxygen and nitrogen in the various wave-length regions at different altitudes. They reported on a new mechanism by which increases in solar ultraviolet are felt low in the earth's atmosphere as a result of a process which in effect transforms the ultraviolet into absorbable infrared.

Amateur Astronomers

New York Amateurs Establish Observing Program

ALTHOUGH the Amateur Astronomers Association in New York City has close to 700 members, the majority are residents of crowded areas where lights and haze present disheartening difficulties for observers. Previous attempts to organize serious observing programs have resulted in loss of enthusiasm through lack of meteorological co-operation. Even the most warmly enthusiastic amateur cools off after traveling several hours to a destination where observation is theoretically possible, only to find that by the time of arrival it is *practically* impossible.

A committee created in June, 1952, to study means for an AAA observing group to contribute work in the amateur field appears now to have solved, at least partially, the problem of how city dwellers can participate in the program. The plan is a variation of the Mohammed-mountain transposition: Instead of trying to get people to telescopes, why not get telescopes to people?

There were not enough telescopes to fill all individual needs, but the Optical Division, which has its headquarters in the Hayden Planetarium basement, had half a dozen or more 6-inch Newtonian reflectors for loan to members. It was decided to make these available for observing in locations selected on the outskirts of the city.

A general notice was sent to the entire membership with a rough outline of the proposal, and a meeting was scheduled at the American Museum of Natural History. In order to insure a working group of bona fide enthusiasts, two dollars were required for registration, the proceeds to go eventually to the acquisition of observing equipment.

At the meeting, it was explained that all registered members would have observing time made available to them within reasonable distances of their places of residence; auto-owning members would assist those without transportation; and regular time would be allotted to pairs or individuals according to their preferences. Each registrant was asked to fill out a questionnaire.

From the data thus provided, 25 registered members have been divided into five local groups: Westchester, including the Bronx; New Jersey; Kings County; Queens County; and Nassau County on Long Island. Residents of Manhattan itself would select the group most convenient for each individual. This simple framework can be expanded and improved with time. The Westchester, New Jersey, and Nassau divisions have already found favorable locations and housing for their telescopes.

Each division is under the supervision of a member of the committee who draws up detailed schedules and enforces operating rules. Not more than six observers are being allocated to each 6-inch reflector, so that each member will have the free use of the telescope at least one night each week. In return, he is expected to devote his allotted time to observing or to withdraw for some more conscientious member.

On the fourth Friday of each month, the group will meet as a whole, to discuss observing techniques and to indoctrinate newcomers. The activities of the various divisions will be compared, and requests for specific data from the observers will tighten up an otherwise loosely knit organization.

Observing will as far as possible be integrated into programs already in operation. Dr. Charles P. Olivier, president of the American Meteor Society, has already suggested co-operation in the recording of telescopic meteors and better coverage of fireballs throughout the New York area. With 13 of our registered observers expressing interest in meteor work, Dr. Olivier's suggestions should certainly be followed.

The American Association of Variable Star Observers, the Association of Lunar and Planetary Observers, and the National Geographic-Cornell University auroral program have all been invited to provide specific assignments. Seven of our members are interested in variable star work, six in planetary observing, six in lunar studies, four in solar work, and three in observing the aurora.

It is hardly to be expected that this new group will come up with very much of scientific value even under these improved arrangements; nevertheless, the opportunity thus provided for otherwise inactive urban amateurs to develop into experienced observers may bring dividends in the future.

Edgar M. Paulton, chairman
Observing Group Committee
Amateur Astronomers Association
American Museum of Natural History
New York 24, N. Y.

RESERVATIONS FOR LEAGUE CONVENTION AVAILABLE

AS ANNOUNCED on page 70 of the January issue, the 1953 general convention of the Astronomical League will be held in Washington, D. C., over the Labor Day weekend, September 4-7. Registration and all sessions will be held at the Carnegie Institution of Washington, located at the corner of 16th and P Sts., in Northwest Washington. The housing accommodations will be at the Cairo Hotel, located on Que Street near 16th, 1½ blocks from the Carnegie Institution.

As the city is a great sightseeing attraction, especially on a long weekend, all interested persons are strongly urged to make plans and reservations now. The registration committee will handle reservations, at the Cairo Hotel only, for the convention period and, if desired, for several days preceding and following the convention dates, all at the following special convention rates:

Single room without bath	$3.00
Double room without bath	$4.00
Single room with bath	$5.00
Double room with bath	$6.00

There are also special rates for family groups of three or four persons using two double rooms with connecting bath. All hotel reservations must be covered by a deposit.

The committee suggests that each interested person forward $1.00 to cover the registration fee for the convention, and complete information will be mailed as it becomes available. Early registration will help defray preliminary expenses of the convention, and will be of value in the formation of convention plans. Registrations should be sent to Mrs. Ione Alston, 20 Plattsburg Court, N.W., Washington 16, D. C., who is chairman of registrations.

There will be ample space at the Carnegie Institution for all types of amateur astronomical exhibits, and a limited number of commercial exhibits will be included. It is hoped also that several Washington area scientific agencies will present exhibits of activities that will be of interest to amateur astronomers. Prospective exhibitors should write to Miss Mabel Sterns, 2517 K Street, N. W., Washington 7, D. C., who is exhibits chairman.

The National Capital Astronomers, host society, has complete charge of all convention arrangements with the exception of the program. Other chairmen of the various working committees are: A. Robinson, publicity; Leo Scott, trips; Lyle Johnson, facilities; Elizabeth Fazekas, treasurer; Mrs. Janet P. Wright, hospitality. The program chairman will be appointed by Rolland LaPelle, president of the Astronomical League.

G. R. WRIGHT
League Convention Manager
202 Piping Rock Drive
Silver Spring, Md.

NEW HAVEN ACTIVITIES

In the past, many people and organizations have asked to be placed on our regular mailing list to receive monthly notices of meetings and other announcements of the Astronomical Society of New Haven. This was fine as long as the list remained small, but after several years it had accumulated a large number of names and was costing the society quite a bit to maintain. Now we charge a $1.00 application fee, which is paid just once, in addition to the dues the first year. This comes at a time when the applicant is very desirous of affiliating with the association and is, therefore, willing to pay the charge. This arrangement has been a great help in defraying the expenses of our ever-growing membership list.

At our meetings we serve refreshments,

our members being very partial to coffee. Over the years we have recovered some of the outlay for a 48-cup electric urn we bought by renting it to other groups or to individuals. We charge $1.00 for an afternoon or evening when the urn is used under the supervision of the astronomical society, and $2.00 if it is used by an outside organization or individual.

We are coping at present with the problem of incorporation. There seems to be very little published information available, and we would appreciate hearing from other societies who have taken this step, so their experience concerning procedure and cost could be made available.

MRS. EVERETT S. RADEMACHER
Astronomical Society of New Haven
449 Ridge Rd., Hamden, Conn.

THIS MONTH'S MEETINGS

Buffalo, N. Y.: Buffalo Astronomical Association, 8 p.m., Buffalo Museum of Science. Mar. 4, Charles R. Burrows, Cornell University, "Radio Telescopes and Astronomy."

Cambridge, Mass.: Bond Astronomical Club, 8 p.m., Harvard College Observatory. Mar. 5, Robert C. Cowen, **Christian Science Monitor**, "Let's Use the Press."

Cleveland, Ohio: Cleveland Astronomical Society, 8 p.m., Warner and Swasey Observatory. Mar. 20, Dr. Walter Baade, Mount Wilson and Palomar Observatories, "Stellar Populations."

Dallas, Tex.: Texas Astronomical Society, 8 p.m., Texas Bank and Trust Co. Mar. 23, demonstration, Spitz planetarium; film, Nautical Astronomy.

Geneva, Ill.: Fox Valley Astronomical Society, 8 p.m., City Hall. Mar. 10, Frank Hancock, book reviews.

Indianapolis, Ind.: Indiana Astronomical Society, 2:15 p.m., Central Library. Mar. 1, Russell Sullivan, "Notes on Bright Stars."

New York, N. Y.: Amateur Astronomers Association, 8 p.m., American Museum of Natural History. Mar. 4, Dr. Carl L. Stearns, Van Vleck Observatory, "Sir William Herschel, Amateur Astronomer."

Junior Astronomy Club, 8 p.m., American Museum of Natural History. Mar. 20, Dr. Lyman Spitzer, Jr., Princeton University Observatory, "Interplanetary Travel."

Pittsburgh, Pa.: Amateur Astronomers Association of Pittsburgh, 8:15 p.m., Buhl Planetarium. Mar. 13, Rolland R. LaPelle, president, Astronomical League, "Amateur Telescopes on the West Coast."

Port Arthur, Tex.: Port Arthur Astronomy Club, 7:30 p.m., home of Mr. and Mrs. W. C. Piggott, 5228 Fifth St. Mar. 12, Mrs. H. H. Dilworth, "A Scientific Approach in Reference to the Biblical Creation."

Rutherford, N. J.: Astronomical Society of Rutherford, 8 p.m., YMCA. Mar. 5, Frederick Waite, "Tides."

Washington, D. C.: National Capital Astronomers, 8:15 p.m., Commerce Building auditorium. Mar. 7, Dr. Alfred H. Mikesell, U. S. Naval Observatory, "New Studies of Star Twinkling."

AN AMATEUR VIEWS SOUTHERN SKIES

WHERE does Orion stand on his head and the Northern Cross skim the horizon? In South American skies. At first, having the sun swing through the northern sky followed by a crescent moon whose horns pointed north was very confusing. But we soon learned to prize a northern exposure in order to enjoy sun baths on the ever-present balconies.

Scorpius and Sagittarius shine overhead, and freed of the haze along the horizon in which we usually see them, harbor a luminous white path, the Milky Way. The Coalsack in the Southern Cross, that dark patch of obscuring cloud, is all the more noticeable for the brilliance of the Milky Way. And at last I have seen the Magellanic Clouds, ghostly flickers of many stars.

My husband was sent by the Bureau of Plant Introduction, U. S. Department of Agriculture, to collect seeds and plants in South America that might prove useful to farmers and ranchers in our country. My 6-year-old daughter and I accompanied him, and there followed seven months of travel, for me, star map in hand.

At Santiago, Chile, we took a funicular up Cerro San Cristobel, a dry hill rising above the city. This has been landscaped into a park with a zoo. On one spur stands Foster Observatory, now operated by the Universidad de Catolica de Chile. Dr. Heilmaier, the director, introduced me to his two assistants, and we laboriously conducted a conversation in some English and Spanish while we looked at the instruments. As we subsequently heard everywhere, South Americans have difficulty, because of monetary and postal restrictions, in obtaining American scientific literature; they are grateful for all they receive.

In Argentina, Buenos Aires is home for the Asociacion Argentina Amigos de la Astronomia. This enterprising group has privately financed a handsome observatory with a library, classrooms, telescope making rooms, offices and a lecture hall. The roof is built on several levels with separate observing areas, so a number of people can work without disturbing one another. The telescope is loaned by the Observatory of La Plata, but other equipment and exhibits have been constructed by the members.

The night of our visit was fine and clear. Senor C. Segers, secretary of the association, showed us several objects, among them the beautiful Jewel Box in the Southern Cross. Arrangements had been made to visit the Observatory of La Plata. However, the Argentine vice-president died in the early morning hours the day of our visit, and everything was closed.

Our stay in Uruguay was too brief to include astronomical activities. In Porto Alegre, Brazil, at the Universidad Rio Grande do Sul, we climbed up into the tower observatory. Their main program is concerned with star transits and time signals for the state. There is an 8-inch refractor with circles but no driving clock. We saw a large sunspot group, which failed to impress my daughter, who wanted to rent a tricycle and ride about the zoo across the street. She did just that after I had exhausted my Spanish and was lost in their Portuguese.

We were at the magnificent falls of Iguazu along the borders of Argentina, Paraguay, and Brazil, during the annular eclipse of August 20th. At the hotel there were a few animals in captivity — every town seems to have a zoo of local animals — but they were undisturbed by the purplish-brick color of the sunlight. Nor did humans notice the striking change in the light until I began observing through old film and taking photographs. Then a few people became curious. The hotel manager blackened glass over a candle so all the guests could watch the show.

Iguazu is on a high plateau in the Araucaria forest, far from any town. It can be reached only by boat or plane unless you prefer pack trips. Away from the lights the stars are so many and bright that it is difficult to identify the constellations. As twilight deepened into night, the zodiacal light was clearly visible in the west.

DOROTHY E. SCHOOF BEETLE
609 Russell St.
Laramie, Wyo.

NEW LOUISIANA SOCIETY

The Lake Charles Amateur Astronomers Club, organized in October, 1952, has become the second active amateur group in Louisiana. The club already has a 3½-inch reflecting telescope in use, as well as a 3-inch refractor, and plans are shaping up for the construction of a 6- or 8-inch reflector.

The Lake Charles group now has 15 members and has been meeting every other Tuesday.

NORMAN G. LORE
532 Alamo St.
Lake Charles, La.

Vernal Equinox

Behold the Vernal Equinox.
He doesn't roam in herds or flocks.
He has no form of frame or face,
He's nothing but a point in space.
He gets no burrs stuck in his hocks,
He's not retained by bars or locks,
He answers not to people's knocks,
We use him, though, for setting clocks.
You may have seen a farmer's ox,
But not the Vernal Equinox.

ALFRED M. PERKINS

NEWS NOTES

By Dorrit Hoffleit

FOREST RAY MOULTON

At the age of 80 years, Dr. Forest Ray Moulton died in Illinois on December 7, 1952. As a teacher of astronomy at the University of Chicago from 1896 to 1926, he was most interested in celestial mechanics, such as the four-body problem and the resistance of comets passing through the sun's corona. Many of the mature astronomers of today were initiated into the field by means of his textbooks on descriptive astronomy and celestial mechanics. He was coauthor of the Chamberlin-Moulton planetesimal hypothesis of the origin of the solar system, which involved the encounter of the sun with a passing star.

He was also concerned with ballistics, and was a major in the U. S. Army at the close of World War I. Secretary of Section D (Astronomy) of the American Association for the Advancement of Science from 1913 to 1924, Dr. Moulton also served as permanent secretary of the association from 1937 to 1946, and as administrative secretary thereafter.

STORMS ON JUPITER

A correlation found by Dr. Clarence E. Palmer, of the University of California at Los Angeles, between solar flare-ups and upper-level cyclones and tropical rainstorms on the earth, suggested to his colleague, Dr. Yale Mintz, that a similar relation might hold on the planet Jupiter. Working at Lowell Observatory under a contract with the Air Force Cambridge Research Center, Dr. Mintz studied the spots that appear periodically on Jupiter, and he concluded that they are high-level storms triggered by the same solar mechanism that initiates cyclones in the earth's upper atmosphere over the tropics. The University of California release concerning this work further comments that there is a tendency for the Jovian spots to form a few days after pronounced solar disturbances and that they are more frequent during years of sunspot maxima.

RAS GOLD MEDAL

One of the highest awards in astronomy, the gold medal of the Royal Astronomical Society, has been awarded to Dr. S. Chandrasekhar, University of Chicago, for his development of new mathematical tools for the study of astronomy. A member of the University of Chicago faculty since 1937, Dr. Chandrasekhar was recently named to hold the Morton D. Hull distinguished service professorship.

He was the first astronomer to study the internal constitution of stars in the light of modern atomic theories. He began his career as an astrophysicist in England with R. H. Fowler and E. A. Milne, and the current theory explaining super-dense stars was developed by him during his fellowship period at Trinity College. He is now best known for his theoretical researches in stellar spectra, the motions of stars, and stellar atmospheres.

SIMULTANEOUS ECLIPSE AND CORONAGRAPH PHOTOGRAPHS

Although it is more than a solar cycle since regular use of Lyot-type coronagraphs began, comparatively little has been published on direct comparisons of coronagraph pictures with direct simultaneous observations at times of total eclipses. Along with a report of a colloquium on last February's eclipse, the *Observatory* for October, 1952, carries a preliminary report in which H. von Klueber, Cambridge, England, briefly compares coronagraph records with direct coronal photographs (similar to those on the back cover of this issue of *Sky and Telescope*).

On "hard" copies of corona photographs taken by the Cambridge expedition (focal length of camera, 200 centimeters), Dr. von Klueber has superimposed graphs of intensity estimates of the green coronal line, at 5303 angstroms, as observed by coronagraphs at the Pic du Midi, France, Wendelstein, Germany, and Kanzelhoehe, Austria, all of them practically simultaneously with the eclipse. The intensities represent the inner corona at a fixed distance of about one-half minute of arc from the sun's limb.

He stresses the fact that the two types of observations do not, in fact, represent the same phenomena. The direct eclipse photographs show the part of the corona's light originating from scattering by free electrons, and the intensity depends on the number of free electrons. Coronagraph observations, on the other hand, are of the emission lines in the spectrum of the corona. Thus, one kind of observation refers to the continuum, the other to line excitation.

Nevertheless, some correspondence between the two sets of observations is found. There is an indication of definite shifts between the positions of maxima of green-line intensity and the typical long streams of the outer corona. A very long thin spike photographed at position angle 140°, however, coincides well enough with an increase in green-line intensity at about position angle 137°.

Observations of the red coronal line at 6374 angstroms appear to have been made on eclipse day only by the High Altitude Observatory at Climax, Colo., and there is a suggestion of intensity maxima at position angles 76° and 256°. The first of these coincides nearly with the long streamer in the corona on the right side of the back cover picture, where north is at the bottom. Unfortunately, Dr. von Klueber did not receive the Climax observations in time to publish them with his other data.

ANIMAL BEHAVIOR ECLIPSE EXPEDITION

From time immemorial the behaviors of various animals during total eclipses of the sun have been casually remarked. Most species behave much as they would after sundown. Heretofore, probably the only time when observations were specifically made for the determination of animal behavior was during the eclipse of August 31, 1932; the results were published by the American Academy of Sciences.

Now, Dr. Neal A. Weber, of the College of Arts and Sciences at Bagdad, has published the details of observations at the February, 1952, eclipse in Iraq. He and his students in zoology observed the habits of mammals, reptiles, amphibians, and insects on other than eclipse day, for comparison with their minute-by-minute behavior throughout the eclipse. In general, this work confirms previous impressions, but the facts obtained are more specific than any formerly available.

IN THE CURRENT JOURNALS

WONDERS OF A "SUN POWER AGE," by Robert West Howard, **Think,** December, 1952. "The greatest scientific progress during the second half of the 20th century may well be in the realm of sun power."

THE EARTH'S ATMOSPHERE, by Joseph Kaplan, **American Scientist,** January, 1953. "For centuries man has searched the heavens for new ideas, but no one can predict what he will find when he has conquered space. But conquer he must, for when man no longer has the desire to learn, he has lost the desire to live."

PHOTOGRAPHY AND THE AMATEUR ASTRONOMER, by G. Merton, **Journal,** British Astronomical Association, December, 1952. "The subject of astronomical photography is too large a one . . . for me to do more than touch very sketchily on a few of the aspects which may interest you, and to remind you of the very large part played by amateurs in developing this tool which has so completely revolutionized the science of astronomy."

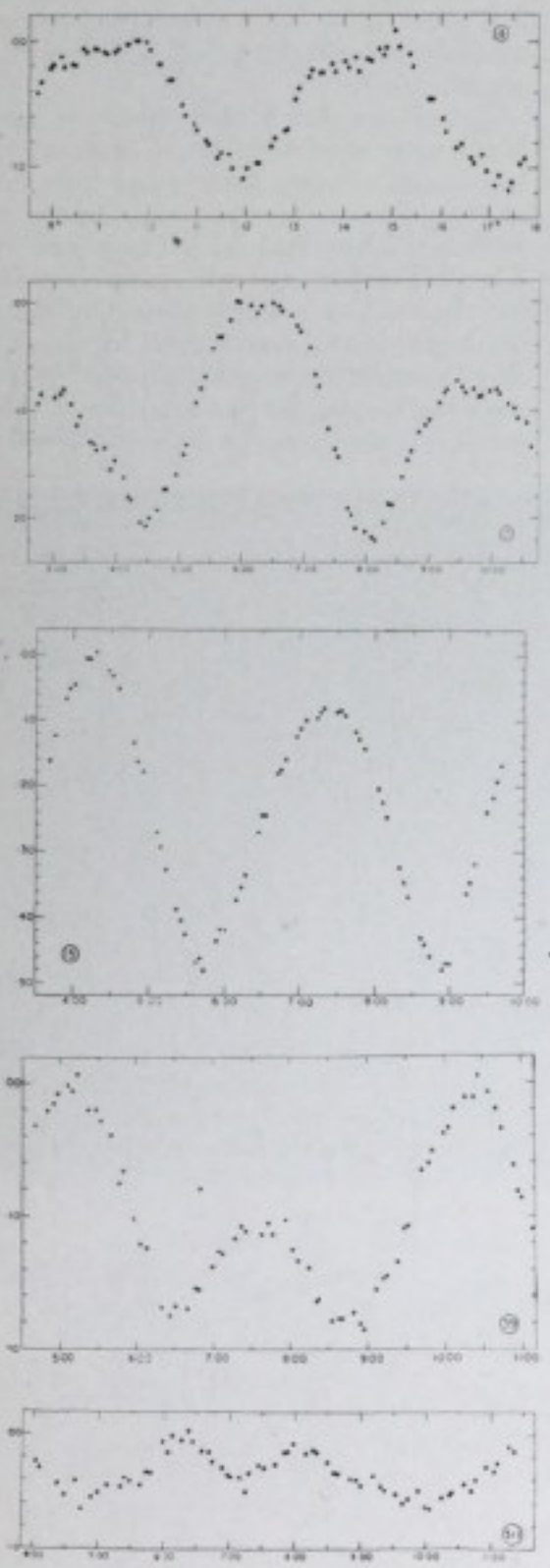
THE 48-INCH SCHMIDT-TYPE TELESCOPE AT PALOMAR OBSERVATORY, by R. G. Harrington, **Publications,** Astronomical Society of the Pacific, December, 1952. An illustrated article describing the principal features of the instrument gives also some detailed specifications of the optics and the mounting.

American Astronomers Report

Here are highlights of some papers presented at the 88th meeting of the American Astronomical Society at Amherst, Mass., in December. Complete abstracts will appear in the Astronomical Journal.

Asteroid Light Curves

The minor planets shine, as all the planets do, by reflecting sunlight. Therefore variations in their light must be related to their shapes, rotations, and irregularities in their surfaces. Recently, a beginning was made at the McDonald Observatory with systematic photometry of the brighter asteroids with a photoelectric photometer. The work was done by Drs. G. P. Kuiper and Daniel Harris, III, and I. I. Ahmad, of Yerkes and McDonald Observatories, as part of a larger program on the asteroids and other solar system objects.



Yerkes Observatory diagrams.

Ten asteroids have been observed so far, and light curves were presented for five of them; these are reproduced here. The reductions for the other five asteroids are being completed. The following remarks apply to each of the light curves in turn.

4 *Vesta.* A preliminary light curve was published by Stephenson (*Astrophysical Journal, 114*, 500, 1951), based on one night at McDonald and six nights at Yerkes Observatory, when Vesta was situated at right ascension 3^h, declination $+10°$. A single night's run (shown here) was obtained by Dr. Harris on March 7, 1952, when Vesta's position was $10^h.8$, $+19°$. The light curve was then distinctly different from a sine curve, although the amplitude was no greater than before, 0.10 magnitude.

7 *Iris.* Two full runs were obtained, one of which is shown here (January 28, 1952). The period is seven hours, seven minutes, or 0.297 day, not 0.259 day as given in the older literature. The amplitude is 0.22 magnitude, the secondary maximum 0.08 magnitude below the primary.

15 *Eunomia.* Four runs were obtained, three in 1950 and one on January 25, 1952, the last being shown here. The period is six hours, five minutes, exactly twice that announced before. The minimum is 0.49 magnitude deep and the second maximum is 0.08 below the first.

39 *Laetitia.* The illustration shows the second of two runs, January 29, 1952. The period is five hours, 13 minutes, or 0.217 day. An early period of 0.092 day was not confirmed. The amplitude is 0.18 magnitude, the second maximum being 0.11 magnitude below the first.

511 *Davida.* This object has the smallest range of light variation so far encountered, 0.06 magnitude, with the second maximum 0.01 magnitude below the first. The period is five hours, three minutes, or 0.210 day. The date of the observations was January 26, 1952.

The observations of the last four objects were made jointly by Drs. Harris and Kuiper; the reductions were made by Mr. Ahmad, a visiting Egyptian student astronomer. The colors of these five asteroids were constant with phase within 0.01 magnitude. The lengths of the periods, five to seven hours, are consistent with stability in the presence of rotation for bodies of presumed density about 3.5, the lower limit of the stable rotational period being about three hours.

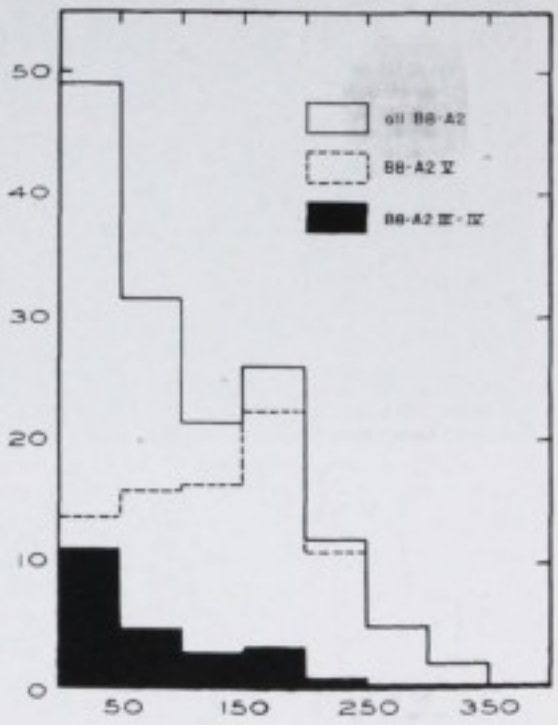
Rotations of Early-type Stars

The fact that some classes of stars are in rapid axial rotation while others are not is of great importance for the problem of stellar evolution. It is generally known that axial rotation of single stars is limited to those of early spectral type; those later than about *F*5 do not rotate with appreciable velocities.

Among the early-type stars, however, the dependence of axial rotation on spectral type and luminosity is not altogether clear. Dr. Arne Slettebak, of Perkins Observatory, described an investigation that is part of a larger program of studying rotation in the brighter stars of early type.

Spectrograms of 178 stars of types *B*8 to *A*2, brighter than magnitude 5.0, were obtained with the 69-inch reflecting telescope of the Perkins Observatory, with a dispersion of about 27 angstroms per millimeter at $H\gamma$. Observationally, two data must be accurately obtained from the plates: spectral types and rotational velocities (based on line widths). The spectral types and luminosity classes were estimated for all normal stars on the Morgan-Keenan-Kellman system. Equatorial rotational velocities multiplied by the sine of the inclination of the axis of rotation ($v \sin i$) were determined for all stars by comparing observed profiles of the MgII 4481 line in each star with a set of profiles computed by the graphical method of Shajn and Struve.

The sharp-lined stars Sirius and Vega



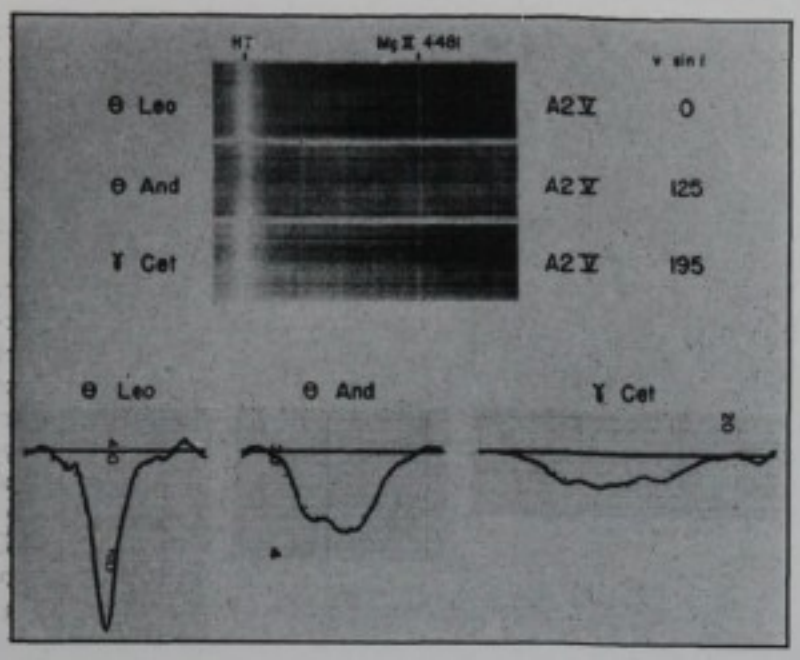
The numbers of stars (ordinate) for observed values of v sin i are plotted here. "All B8-A2" includes all types of stars involved in the study. Perkins Observatory diagram.

were selected as nonrotating standard stars and used to compute the comparison profiles. The v sin i for any given star was the mean of two independent determinations, since two spectrograms of each star were measured. Eighty-seven stars of luminosity class V had average v sin i rotations of 137 kilometers per second; 24 stars of classes III-IV, 73 kilometers per second. For the peculiar A and metallic-line stars, v sin i averaged about 40 kilometers per second, but for these and the supergiant stars (less than 26 kilometers per second) the results are not too significant in view of the small number of samples considered; it can only be said that these groups have relatively little axial rotation.

When the projected (v sin i) rotational velocities are changed to mean true equatorial velocities, on the assumption that the axes of rotation are randomly distributed in direction, the velocities in kilometers per second are: $B8$-$A2$ V, 174; $B8$-$A2$ III-IV, 93; peculiar A, 52; metallic line, 51; and supergiants, less than 34.

Thirty-six stars were not included in the results, as being earlier in type than $B8$, later than $A2$, or having peculiar spectra.

Of particular interest is the difference in axial rotation between the main-sequence stars and the giants and subgiants, the more luminous stars having generally smaller rotational velocities. If this difference is real, the relation between axial rotation and spectral type among the early-type stars should be considered by luminosity class.



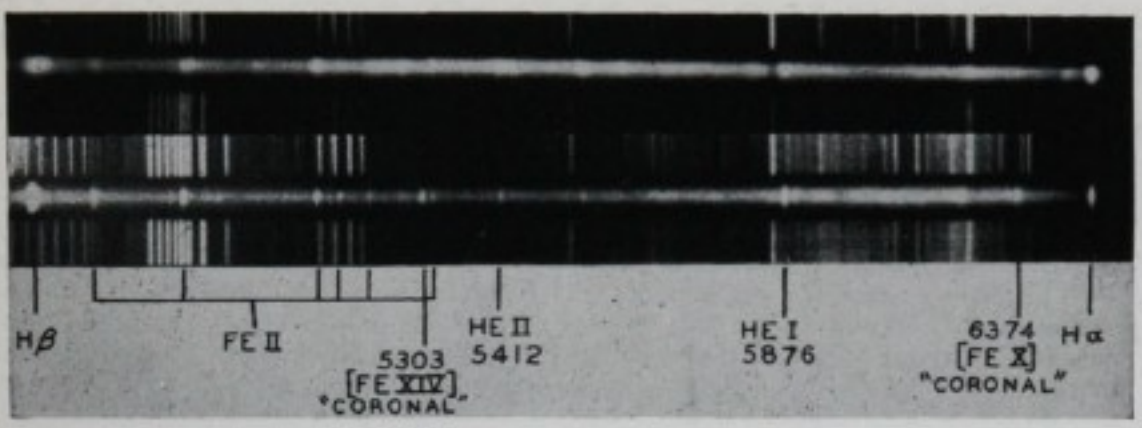
The spectra of three stars of the same class are here compared to illustrate the effect of line broadening. In each case the profile of the MgII 4481 line is shown; the highest velocity gives the broadest, shallowest profile. Perkins Observatory photograph.

Novae Coronal Lines

Until 1933, the bright lines that are so characteristic of the spectrum of the sun's corona were unknown in any other source. In that year, Adams and Joy at Mount Wilson found some of these lines very strong in the spectrum of the repeating nova RS Ophiuchi. Since then, two other recurrent novae have shown some of these lines, especially the red and green ones, due to the iron atom in a highly ionized state (FeX and FeXIV, respectively).

Dr. Dean B. McLaughlin, of the University of Michigan Observatory, has made a search for coronal lines on spectrograms of several novae taken at Mount Wilson and Lick observatories. The green line was not found at all, but the red line is surely present in some of these stars. Identification of the red line depends in every case upon disentangling a complex emission band, for in all novae the bright lines are greatly

Members and guests at the 88th meeting of the American Astronomical Society, Amherst College

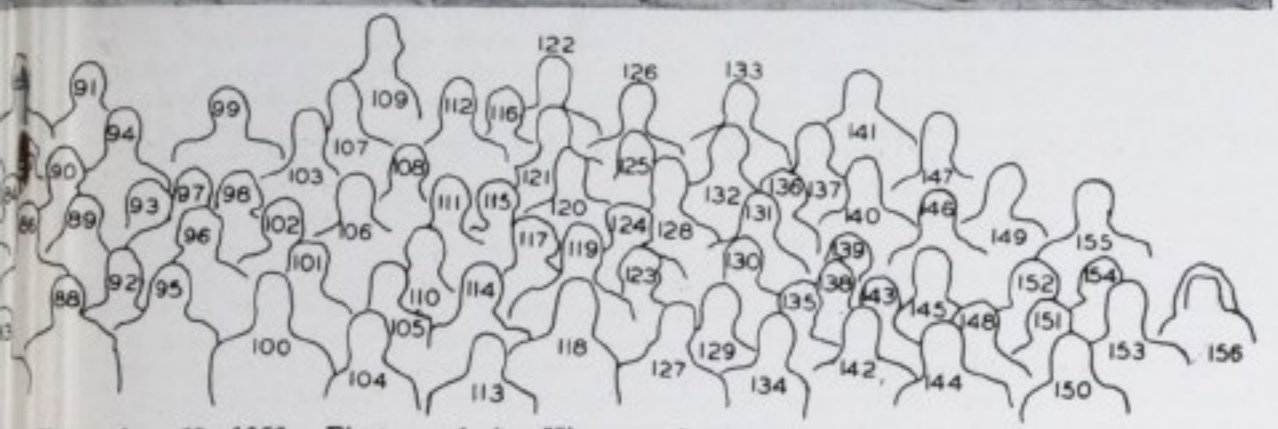


Spectra of T Coronae Borealis, a recurring nova, taken by Dr. McLaughlin on February 11 and 16, 1946, two and seven days after maximum light. University of Michigan photos.

widened by the Doppler effect of the high speed of expansion of the gases ejected from the star. Hence, bright lines often overlap, but Dr. McLaughlin has been able to recognize features that are not satisfactorily identified as anything but the red coronal line.

He is certain of his identifications in Nova Aquilae 1918 and Nova Puppis 1942, and almost certain for Nova Lacertae 1936 and Nova Geminorum 1912. In three other cases, the evidence was inconclusive.

The red coronal line is apparently a normal feature of nova spectra, though its strength varies greatly from one nova to another. It first appears about the same time that the characteristic "nebular" lines of doubly ionized oxygen emerge to view, a few weeks after the nova has passed its light maximum. The line lasts for at least a few months, but its later behavior is uncertain, due to scarcity of observations.



, December 29, 1952. Photograph by Kinsman Studios.

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BOOKS AND THE SKY

THE HISTORY OF ASTRONOMY

Giorgio Abetti. Translated by Betty Burr Abetti. Henry Schuman, New York, 1952. 338 pages. $6.00.

HERE is the history of astronomy in English which has been needed for a long time. The only satisfactory up-to-date books in this field that have covered more than the period since 1850 have been the sound though strongly slanted works of Ernst Zinner. **Astronomie, Geschichte ihrer Probleme,** Munich, 1951, is his latest.

For the majority who limit all but their barest reference reading to English, there has been the inadequate **A Concise History of Astronomy,** by Peter Doig, largely an unadorned topical treatment, and **A Hundred Years of Astronomy,** by Angus Armitage, good as far as it goes. The volume reviewed here is, however, a very different affair.

Giorgio Abetti is well known to English and American astronomers, not only for his accomplishments as director of the solar observatory at Arcetri for nearly 30 years, but because his book on the sun has been required reading for earnest students for more than half that time—ever since it was translated. Now he has turned a talented pen to the whole range of astronomy and its evolution to the present. (For a review of the Italian edition of this book, see **Sky and Telescope,** April, 1950, page 142.—ED.)

It is always perilous for a scientist to try to evaluate the work of his contemporaries against the background of long tradition and partisan rivalries. Dr. Abetti shows himself to be serenely unbiased and blessed with true historical perspective. If the reader is conscious of the considerable space devoted to lesser Italian astronomers, it is in large part a reflection on the Nordic versions of the development of the science.

At the risk of overemphasizing the Italian features, it can be said that embroidered on a magnificent history there are to be found ornamental pieces about the author's countrymen that make them live as they should. We mention two powerful figures in the history of astronomy who usually get short shrift today. One is Father Angelo Secchi, founder of spectral classification and pioneer in astrophysics.

The other is G. V. Schiaparelli, celebrated as the man who precipitated the 50-year row over the reality of the "canals" of Mars and as the uncle of the Schiaparelli who started a lucrative dress business. Actually, his contributions to astronomical knowledge extended across the planetary front, and he remains to this day a brilliant example of a scientist able both to advance the current research and to bring new insight to historical problems. He wrote extensively on astronomical history, but very little of his work found its way into English. Now, 40 years after his death, Abetti has exhibited the same qualities in abundant measure in giving us this book.

The History of Astronomy enjoys the benefit of Schiaparelli's scholarship and that of more recent men, all presented in an engaging but too slim volume. In spite of the brevity, it can be accepted as a standard work. As always in a modest book, references are not noted, and it is hard to get back to sources except where the date of publication is given. Because birth and death dates follow names, the index is especially useful. The well-chosen illustrations are all in one section; Numbers 6, 7, 11, and 13 reproduce exquisite plates from Andreas Cellarius' great atlas of 1661, but their origin is not stated in the book. A few proofreading errors should be corrected in a future edition.

Even with the space limitation, the author manages to introduce actual quotations long enough to allow the nature of the astronomer under discussion to come through. Of many successful examples of this, we cite excerpts from the writings of Hale and Eddington.

The historian's appreciation of the trends, schools, and turning points in the progress of astronomy is revealed even in the chapter headings. Dr. Abetti does far more than simply credit the right man with the right discovery. He illuminates the basic forces which have animated the figures in every age, shows how they have been influenced by their times and how they in turn colored the background against which successors played their roles.

Astronomers, historians, and the vast numbers who read for their own enlightenment about the progress of man's understanding of nature will all be the richer for this book.

JOHN W. STREETER
Fels Planetarium

AN INTRODUCTION TO ASTRONOMY

Robert H. Baker. D. Van Nostrand Co., Inc., New York, 4th edition, 1952. 306 pages. $4.00.

IN the last seven years there has been published an ever-increasing number of books on the subject of astronomy. Many have been written to appeal to the ubiquitous layman, whose interest in astronomy has perhaps been stimulated by radio and television programs, or by guided-missile projects and space symposia. These popular books admirably serve the purpose of whetting the intellectual appetite for scientific knowledge of our place in the universe. For those, however, who wish to study astronomy seriously and gain a thorough understanding in the fundamentals of the subject, a comprehensive introductory textbook is required. One of the best of these is Robert H. Baker's **An Introduction to Astronomy.**

Employing the same basic material and methods used in his standard college text, **Astronomy,** the author, for many years professor of astronomy in the University of Illinois, first published this simpler book in 1935. It is designed for shorter introductory courses in schools and colleges. The present volume is the fourth edition, considerably revised. The problems of what to include and what to

leave out, what to condense and what to simplify, have been well handled in this work to produce a compact text containing the important elements of the subject. This book is not just a contraction of Dr. Baker's larger volume; it has been written with the beginner definitely in mind.

The scope of the text is perhaps best indicated by a brief description of its chapters. So as not to plunge the student precipitously into the difficulties of celestial co-ordinates, the book begins with a chapter on the earth and the sky, including a short explanation of the horizon system. Chapter 2 takes up the effects of the earth's rotation and gives the simple essentials of the equator system. The text then describes, in another chapter, the revolution of the earth and such matters as precession, the seasons, and the calendar. Time is the subject of the fourth chapter, which includes a short introduction to celestial navigation.

Dr. Baker then devotes 33 pages to the constellations. Since beginning students are seldom familiar with configurations of stars, this part of the book contains a description of the major constellations and their stars — for each of the four seasons. This material does not appear in the author's larger work. The six maps of the more important stars and constellations are particularly lucid.

"Telescopes and Their Uses" is a much-needed new chapter, which was lacking in earlier editions of this book. Refracting and reflecting telescopes are adequately described, as is the spectroscope. The moon, and eclipses of the moon and sun, are the subjects of Chapters 7 and 8. Then the motions of the planets and their aspects, phases, and satellites are explained. After chapters on the planets and on comets and meteors, Dr. Baker gives a short but interesting description of the sun.

"The Stars Around Us" is an up-to-date discussion of stellar motions, spectra, magnitudes, types, and histories. Chapter 14 is devoted to the essential information in regard to double and variable stars. Following this, the author provides an entirely new section called "Gas and Dust in the Star Fields." Here are introduced such timely subjects as stellar envelopes, reflection nebulae, and interstellar dust. The galactic system is then told about in completely revised material to incorporate such concepts as Baade's two types of stellar population. The final and 17th chapter of the book tells about the **exterior** systems, formerly referred to as the **extragalactic** systems.

A considerably expanded bibliography is an added feature of this fourth edition. It is a great help to beginners to know where they can find collateral reading to extend their knowledge of the subject of astronomy. The index is short, and a somewhat fuller one might be an improvement. Only a few prominent astronomers are listed. Notable names, such as Schiaparelli and Hubble, though mentioned in the text, are not to be found in the index.

No astronomy text today is complete unless it contains good photographic illustrations as well as explanatory diagrams and tables. Dr. Baker's book is replete with such; they add tremendously to the value of the volume. This edition includes

Two delightful books about the real, the unreal and the unlikely

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Flying Saucers

by Donald H. Menzel, Professor of Astrophysics, Harvard University. Associate Director for Solar Research, Harvard College Observatory

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by Cecilia Payne-Gaposchkin, Phillips Astronomer, Harvard University

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a number of photographs made with the 200-inch Hale telescope at Palomar. Picture captions are in the main helpful. One, however, could be improved. A diagram of the orbits of Phobos and Deimos appears to show retrograde motion if the reader does not know that an inverted telescope image is represented.

A very valuable part of this text is a quiz program at the end of each chapter. Any student who can answer all of these questions with a reasonable degree of accuracy is ready for a more advanced course in astronomy. The questions are fair and definitely stimulating. A few of them may seem to be a bit ambiguous.

Any textbook that has run through four editions including at least 15 reprintings and is used in schools, colleges, and institutions from coast to coast has proven its worth. **An Introduction to Astronomy** is definitely good, and is highly recommended to all persons who are beginning the study of astronomy.

W. WALLACE BENJAMIN
Amateur Astronomers Association

NEW BOOKS RECEIVED

SIGHT REDUCTION TABLES FOR AIR NAVIGATION, Vol. 1, Selected Stars, Epoch 1955.0, *H. M. Nautical Almanac Office*, 1952, *H. M. Stationery Office*, London. 325 pages. £1 1s.

This is the first of three volumes forming the British edition of the U. S. Navy Hydrographic Office *Publication H. O. 249*, which has been prepared jointly by the U. S. Nautical Almanac Office and H. M. Nautical Almanac Office. Both editions have been reproduced photographically from the same material.

The present volume contains tabulations of altitude and azimuth for all latitudes for six stars selected for each range of hour angle. The latitudes are tabulated in whole degrees from 89° north to 89° south; the altitude is given to the nearest minute, and the azimuth to the nearest degree. A total of 34 stars is used, 19 of the 1st magnitude and 15 of the 2nd magnitude.

These tables are designed for use with the *Air Almanac*, but they may be used with a sidereal clock. It is stressed that the tables should be employed for the planning of observations as well as their reduction. The present volume is expected to apply for the next five years, after which a new set of tables for a later epoch will be issued. Volumes 2 and 3 will be permanent tables for the application of this method to observations of the sun, moon, and planets, and will be published in 1953.

TIME AND UNIVERSE FOR THE SCIENTIFIC CONSCIENCE, *Martin Johnson*, 1952, *Cambridge University Press*. 42 pages. 50 cents; 2s. 6d.

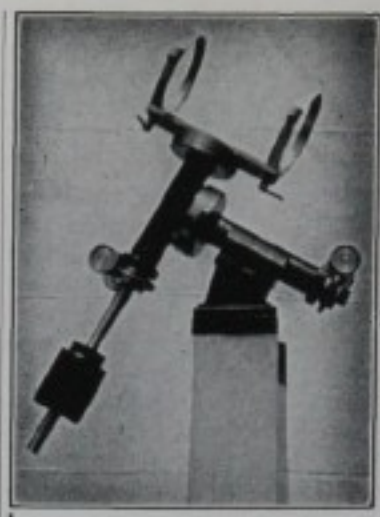
This paper-bound volume contains the text of the sixth Eddington memorial lecture, given in November, 1952.

SIR JAMES JEANS, *E. A. Milne*, 1952, *Cambridge University Press*. 176 pages. $4.00.

In a biography just completed before his own death in 1950, E. A. Milne writes of the life of Jeans, outstanding scientist as well as author of popular books. The second part of the work is devoted to an evaluation of Jeans' contributions to science.

THE EXPANSION OF THE UNIVERSE, *Paul Couderc*, 1952, *Macmillan*. 231 pages. $6.00.

This is a translation by J. B. Sidgwick of Couderc's *l'Expansion de l'Univers*, published in 1950. The text includes some revisions and amplifications of the original book. Some of the comments of the *Sky and Telescope* review (December, 1950) of the French edition have been discussed.



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GLEANINGS FOR ATM's

EDITED BY EARLE B. BROWN

Two Atlanta Telescopes

MY FIRST TELESCOPE was a 6-inch. About the same time that I was making it, Jim Stusak in another part of Atlanta was making a 6-inch. His interest in telescopes dates back to an early acquaintance with a "spyglass" belonging to an uncle. His determination to own a telescope was spurred into action by an article in a popular magazine. He ordered a kit and, working entirely on his own, turned out a very neat 6-inch reflector with a standard pipe-fitting mounting and a wooden tube covered with leatherette. This instrument ultimately proved to be merely a testing device to determine what features Jim wanted in his next telescope.

The first reflector I made was under the direct supervision of Dr. W. A. Calder, of Agnes Scott College; and I must confess that when the mirror was finished I still knew very little about telescope making. Dr. Calder was always at hand to answer questions and actually do the work if necessary. Perhaps it was this blissful ignorance that led me to my second instrument: a 201-inch!

It is really a 16-inch, but by applying the area formula, pi times radius squared, I get 201 square inches. Compare this with the 28 square inches of a 6-inch instrument, and it is evident that a 16-inch telescope is worth constructing.

Jim Stusak's second instrument is a 12-inch. Seeing my name in the paper in connection with some local astronomical activities, he had called me one night to explain a situation that sounded very familiar, for I had often been in the same fix. He had taken a couple of days off, expecting to work on his second mirror,

A 12-inch Newtonian reflector built by Mr. Stusak.

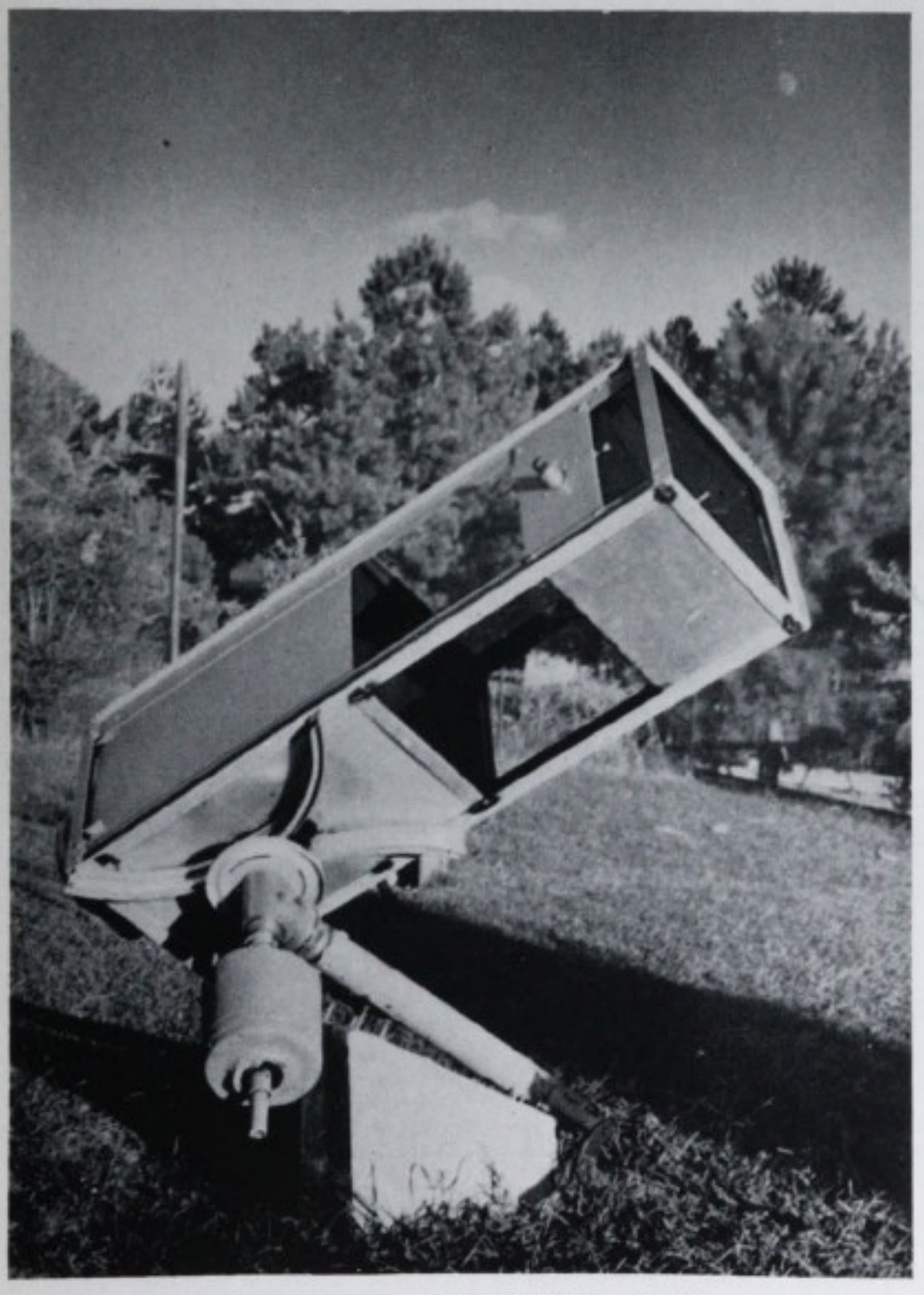
the 12-inch, and found he was without fine-grain carbo and could not locate any in town. I had some and volunteered to bring it over, for I was curious to see what he was doing. I found him in a polishing room rigged with curtains from floor to ceiling, somewhat like an enlarged voting booth, with newspapers tacked to the ceiling, and I knew at once that he had been reading **Amateur Telescope Making.**

The mirror had some scratches, and he was going back to grind them off. It seems he thought nothing of making a pitch lap. Using a razor-sharp case knife to cut channels, he could be polishing on a lap 45 minutes after starting to make it.

After discussing mirror making for a while, he took me to the back yard and unveiled half a ton of concrete cast in a crescent shape. This well-designed monolith was the basis of his mount. My curiosity turned to amazement when, in another part of the basement, he showed me the tube and polar axis. The aluminum tube, 8′ 6″ long and 15⅜″ in diameter, had been hand rolled with a butt joint held by a thin strip bolted down the seam. The tube is lined with ⅛″ cork.

As the picture on page 139 shows, the back of the cell has the appearance of a jeweled watch, for the mirror rests on an 18-point bronze flotation system with knurled brass knobs for adjustments. Spaced along the sides of the tube are ventilating portholes. These, as well as the eyepiece adapter, were cast by Stusak from old license plates and odd bits of aluminum. The tube rotates in two large aluminum rings on ball bearings spaced at 120°; these rings are 20″ apart and are connected by a series of steel rods. The saddle is anchored to the declination axis by a crosspiece.

Jim Stusak bought a lathe; and although he had never operated one, he took the attitude that it was made by man for man's use, so he felt he qualified. If he found some jobs too big for the lathe, he improvised equipment that would handle the work. One of the rough jobs was facing a 6″ cube that had been made from ½″



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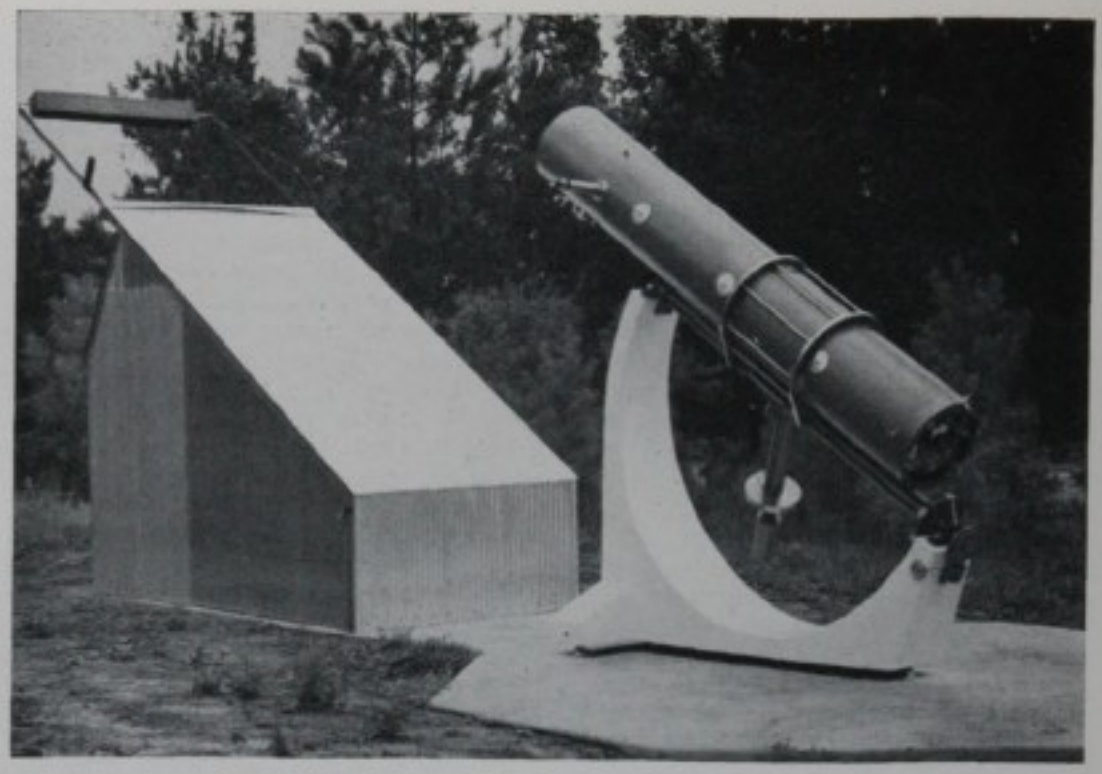
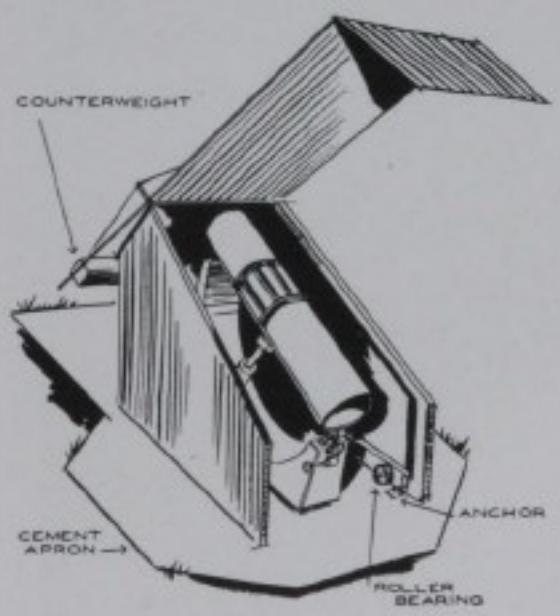


The cover of the Stusak reflector slides off to the north.

steel boiler plate welded together. The cube contains a drive for the declination axis; this axis is a 1½" cold-rolled steel shaft set in roller bearings. The lead-filled, 40-pound counterweight looks like a cylinder of stainless steel and would never betray itself as having once been an old, mutilated, battered and pitted section of drainpipe, that is, before it encountered the magic of the turning tool. The 6' polar axis was likewise an ordinary 3½" pipe turned on the lathe. Self-aligning 1-7/16" pillow block bearings at each end of the crescent support the polar axis.

Mrs. Stusak did a good many of the errands, and became so familiar to the supply house clerks that she was often greeted with, "Here comes that telescope lady." Once, however, she nearly refused some castings because she knew her husband wanted brass, and the invoice indicated bronze.

The entire Stusak instrument is mounted on a key-shaped apron of cement. As the pictures and the sketch show, a sheet aluminum housing with a counterweighted top may be opened quickly. It glides smoothly down the cement on roller bearings, and the observer is ready for another journey into space.



The manner in which the cover lifts to permit access to the 12-inch reflector.

In my own case, after my 6-inch was completed, temptation to try a larger instrument was strong when two friends, John Brown and Conrad Meadors, suggested I join them in ordering a 16-inch disk. I was reminded of an article on tile tools in **Sky and Telescope** (by George F. Joyner, January, 1949), and shortly found myself in possession of a 50-pound chunk of pyrex. Being somewhat conscious of my approaching middle age and expanding midsection, I began to be apprehensive of my physical ability to wrestle with such a project. John Brown advised me to make several small mirrors first just to get the experience, but I was too anxious to get started on the 16-inch. Although I later borrowed his experience, which was invaluable in testing and recommending treatment for the particular difficulties that arose in figuring, needless to say I got most of the experience the hard way.

I ground completely through the tile of the first tool, and disabled the second when some of the tile parted company with the cement base while I was attempting to free a stuck disk. Before finishing the grinding, I had made five tools.

Several years have elapsed since I made the 15 or 16 attempted pitch laps. As the curve was rather deep (f/4.7), I could not use the conventional method of sliding a steaming hot 50-pound glass onto the pitch without getting a generous air pocket in the center. I finally conquered by pouring the pitch onto the mirror, which had been covered with a thin piece of wax paper, and then slapping the tool into the pitch immediately.

Since the bathtub was the only vessel in the house large enough to accommodate the disk and tool, I made preparations there while my long-suffering "glass widow" stirred pitch at the kitchen stove. My wife patiently performed this task each time, and appeared with the pitch in perfect condition at just the precise moment

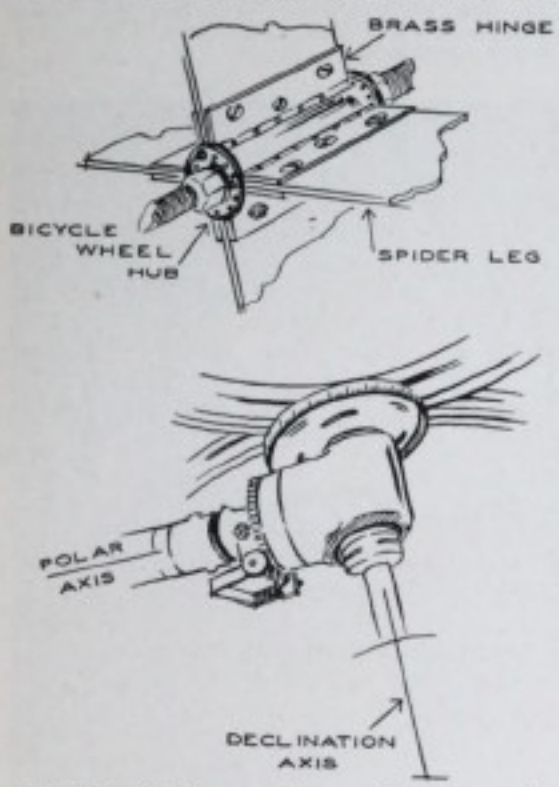
The 12-inch mirror supporting system.

it was needed. Needless to say, much time was spent scraping pitch from all parts of the bathroom.

The first polishing disclosed a hole in the center deep enough to warrant a return to fine grinding. Final figuring was accomplished with a 9-inch tool. To the best of my judgment, with the dubious accuracy obtainable with the Foucault apparatus used, a correction of 98 per cent was attained.

A tense moment was spent when the mirror was returned from being aluminized and I realized that it was not the glass I had come to know so intimately during the 18 months of grinding and polishing. My first inclination was to test it to see what type of mirror they were trying to substitute for mine. A second sense told me, however, that fingerprints would not look good on a professionally made mirror, so I immediately wrapped it up and notified the aluminizers. A reply by wire admitted their mistake and urged me to return the mirror at once—insured for $2,500!

The square tube was made from an aluminum T-beam 3¼" x 2" found in a local scrap yard. In fact, most of the material used came from the same place. The T-beam was cut with a hand saw and bolted together.



Details of the spider and polar-axis clutch on Mr. Close's instrument.

When I first began assembling the instrument in the basement, I found I was repeating the mistake of the man building the large boat in his cellar. The telescope was therefore knocked down and reassembled in my wife's sewing room where, standing on end, it resembled a telephone booth. Perhaps my five-year-old daughter described it more vividly when she saw one of the neighborhood boys flying a box kite and cried, "Look! A flying telescope!"

A lucky find produced 12" aluminum circles marked off in 360 degrees. Apparently these were part of some aircraft directional device. The core that held them together serves admirably for an eyepiece adapter.

The steel strainer section of an Army coffee urn was converted into a mirror cell by cutting out the bottom and fitting it with a nine-point flotation system of cast aluminum. Some years ago I had picked up a retractable screw from an aircraft landing gear. This was 55" long, with a differential housing at one end. I had mounted the 6-inch on it and simply inclined the whole shaft so that the main bearing, a 5" roller bearing upon which the differential housing turned, became the polar axis.

A shaft was run through the housing to form the declination axis. The roller bearings on which the declination rotated were replaced with bronze oilite bearings, thus permitting use of a shaft large enough to

The 16-inch mirror supporting system.

support the 16-inch. Two arcs were cut from a circular track upon which a gun turret or some similar apparatus revolved and were sandwiched between two pieces of steel plate to form an X. The declination shaft was inserted through holes in the plates and welded. The "box kite" rests on the X, as the picture shows.

When I first started grinding the mirror, a fellow amateur ventured to remark, "At least three years." It was three years to the month before I got my first look through the 201-inch.

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OBSERVER'S PAGE

Universal time is used unless otherwise noted.

THE PLEIADES OCCULTATIONS

The occultations of December 27-28 seemed a perfect occasion to try some rapid star photography. I prepared my 17-inch teleanastigmat for the event by attaching to it my Leica camera body, loaded with Super-XX film. The iris was closed to f/11 to cut down the glare of the moon, leaving an effective aperture of 1¼ inches. The assembly was then mounted on a firm tripod.

A few clouds passed over the moon at 6:30 EST, but otherwise the night was very clear and crisp, with a strong wind from the north.

A picture at 7:30 was exposed 10 seconds, to let the stars trail and thus permit identifying them from dust specks and film grain. Among other shots made is the 2-second exposure at 8:12 EST, shown here, enlarged to match the scale of the chart published in the December issue, page 52. This should help identify the stars picked up during the short exposure.

LUC SECRETAN
3219 12th St., S.E.
Washington 20, D.C.

A group of Milwaukee Astronomical Society members timed the Pleiades occultations at their observatory, with another member observing 16 miles to the northeast. At the MAS Observatory, 4-inch and 5-inch refractors and 10-inch and 13-inch reflectors were used on eight stars between 23:14 and 3:56 UT, with three stars observed by all four instruments. These stars were 20 and 22 Tauri and BD +24°562. A list of 24 separate timings has been sent to Mrs. Margaret Beardsley, Springfield, Vt., for reduction with other occultation observations.

All timing was done at the observatory with precision laboratory Telechron clocks (Standard Electric Time Co.), which were started at the instant of the occultation and stopped at the next convenient WWV time signal. A stop watch was used by the single observer at the second station, where each occultation took place about 28 or 29 seconds later than at the observatory.

For any particular occultation, the greatest timing spread between observers was 1.2 seconds, which is too large. It does, however, indicate what can be expected from the human element, especially when there are two co-ordinations to be accomplished: the starting and the stopping of the timepiece. A chronograph that continuously records WWV and then has added to it the occultation "pip" would be more accurate. Most precise would be the use of a photocell to supply the pip, but this method is limited to stars brighter than about magnitude 5, whereas visually stars as faint as magnitude 7 can be observed.

EDWARD A. HALBACH
2971 S. 52nd St.
Milwaukee 15, Wis.

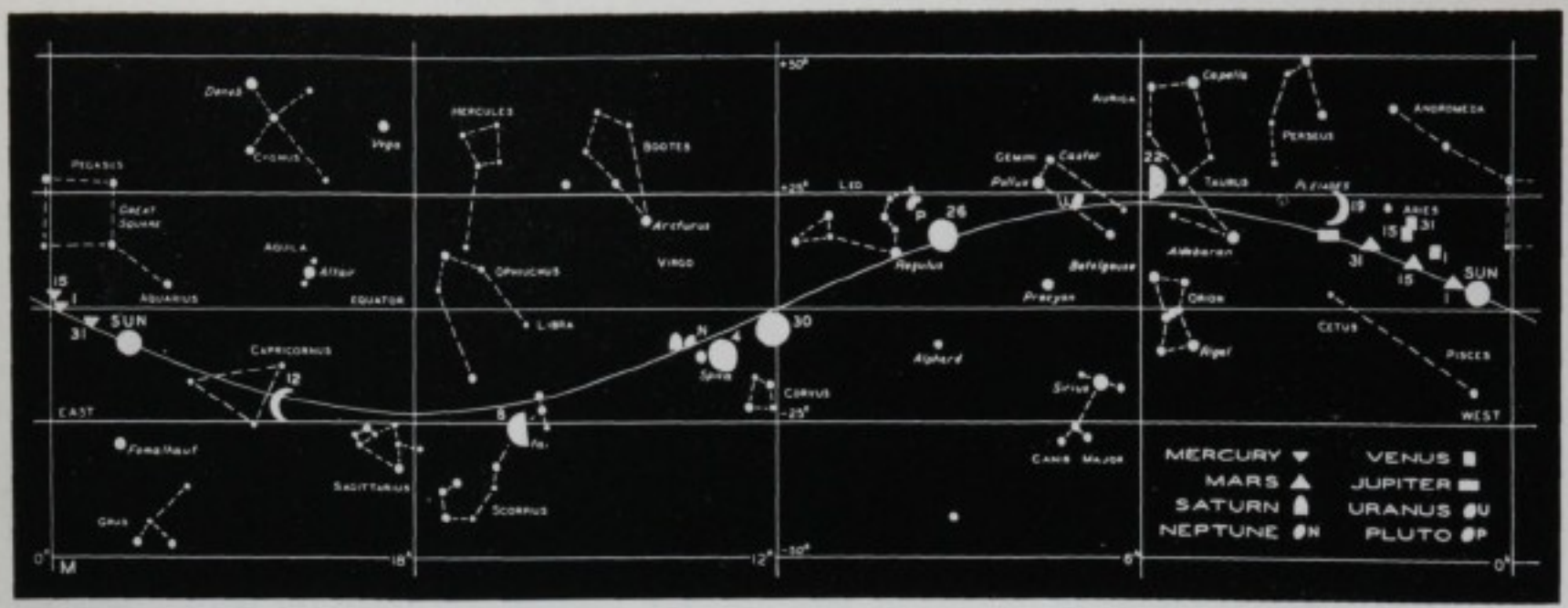
VARIABLE STAR MAXIMA

March 1, RT Sagittarii, 201**139**, 7.9; 3, R Centauri, 140**959**, 5.9; 3, RU Cygni, 213753, 8.0; 4, X Centauri, 114**441**, 7.8; 5, T Normae, 153**654**, 7.4; 6, RU Sagittarii, 195**142**, 7.2; 10, W Lyrae, 181136, 8.0; 15, RS Scorpii, 164**844**, 6.8; 17, U Orionis, 054920, 6.6; 19, W Andromedae, 021143a, 7.5; 23, R Geminorum, 070122a, 7.1; 23, R Draconis, 163266, 7.6; 24, R Sagittarii, 191**019**, 7.2; 26, R Reticuli, 043**263**, 7.7; 26, T Centauri, 133**633**, 6.1; 30, R Bootis, 143227, 7.3; 31, X Ophiuchi, 183308, 6.9.

April 2, T Columbae, 051**533**, 7.6; 4, RS Librae, 151**822**, 7.7; 5, R Pegasi, 230110, 7.9; 8, S Pictoris, 050**848**, 8.0.

These predictions of variable star maxima are by the AAVSO. Only stars are included whose mean maximum magnitudes are brighter than magnitude 8.0. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern), and the predicted magnitude.

A photograph of the moon in the Pleiades, December 27-28, 1952, by Luc Secretan. The stars that are being occulted may be determined by comparing the picture with the diagram in the December issue.



THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month and for other dates shown.

Mercury visits the evening sky only briefly this winter. Greatest elongation takes place on March 2nd, 18° 10′ east of the sun. The planet on that date appears at magnitude −0.2, and is above the western horizon 1½ hours after sunset. A week later, Mercury will vanish into the sun's glare.

Venus, in the western sky after sunset, will be of major interest both to naked eye and telescope observers. Greatest brilliancy occurs on March 8th, at magnitude −4.3; Venus may then be seen in the daytime if one knows where to look.

On March 1st, Venus will set 3½ hours after the sun, telescopically appearing as a crescent with 33 per cent of its disk illuminated and 35″ in diameter. Due to its rapid motion toward the sun, by the end of March its magnitude will have decreased to −3.8, and it will set 1½ hours after sunset. With optical aid, the disk will appear 54″ in diameter with only seven per cent of its surface illuminated.

Earth arrives at heliocentric longitude 180° on March 20th at 22:10 UT. Spring commences in the Northern Hemisphere and autumn in the Southern, with days and nights approximately equal over the earth.

Mars may be viewed in the evening sky as a 2nd-magnitude object near Venus. On the 17th, Mars moving eastward passes 7° 0′ south of Venus. The crescent moon will be found between the pair on that day, 1½° south of Venus.

Jupiter will be to the east of Venus and Mars in the evening sky. The giant planet will set 4½ hours after the sun in mid-month, decreased in brightness to magnitude −1.7. Jupiter remains an interesting object for telescopic study, the equatorial diameter being 35″ on the 15th.

Saturn will rise 2½ hours after sunset on the 15th. Moving westward in Virgo, about 5° northeast of Spica, Saturn will have brightened to +0.5 magnitude in mid-March. The ring system is inclined 14° to our line of sight, with a major diameter of 42″ on the 15th.

Uranus, in the evening sky, may be viewed till morning hours. This 6th-magnitude object resumes eastward motion on March 22nd, but has little apparent movement all month. It is about 2½° north of Zeta Geminorum and approximately ¼° northwest of the variable star R Geminorum.

Neptune will rise shortly after sunset as it approaches opposition next month. Located 3° west of Saturn in mid-month, Neptune will be in retrograde motion.

E. O.

MOON PHASES AND DISTANCE

Last quarter	March	8, 18:26
New moon	March	15, 11:05
First quarter	March	22, 8:10
Full moon	March	30, 12:55
Last quarter	April	7, 4:58

	March	Distance	Diameter
Perigee	14, 23h	222,000 mi.	33′ 26″
Apogee	27, 18h	252,300 mi.	29′ 26″
	April		
Perigee	12, 7h	224,100 mi.	33′ 8″

JUPITER'S SATELLITES

Jupiter's four bright moons have the positions shown below for the Universal time given. The motion of each satellite is from the dot to the number designating it. Transits of satellites over Jupiter's disk are shown by open circles at the left, eclipses and occultations by black disks at the right. The chart is from the American Ephemeris and Nautical Almanac.

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DEEP-SKY WONDERS

THE HEAVENS are vast, and a man might spend several lifetimes without getting anything like a complete knowledge of even the more common celestial glories. But they all ought to be in books. Accordingly, when Dr. C. P. Custer, of Stockton, Calif., pointed out that this column had never listed M47, we confidently opened the library—and drew a complete blank.

One would think that a Messier object would be at least mentioned in the handbooks, but this is what we found: Smyth and Webb make no mention of it. The Norton, Beyer-Graff, and Skalnate Pleso atlases do not record its position. We do not have, unfortunately, the Franklin-Adams plates, but a search of the Ross **Atlas** failed to locate any suspects. The **Handbuch der Astrophysik** gives its NGC number as 2478 and describes it simply as "cluster." In the same book it does not show in the Shapley list of galactic clusters. In the **New General Catalogue** itself we find it listed, but in the description column is the bare word "cluster," a very unusual practice for this book.

Owen Gingerich, at Harvard Observatory, has kindly supplied the following additional notes on the history and fate of M47:

Messier described M47 when he discovered it in 1771 as a "cluster of stars slightly elongated to the west (précédent); the stars very bright." The Herschels, who systematically observed the Messier catalogue, gave no report on the object. When John Herschel compiled the **General Catalogue**, he merely recopied the position from the contemporary Wollaston catalogue, which had, in turn, copied the Messier position. When Dreyer compiled the NGC, he took the Messier positions from Auwers, who had reobserved nearly all of the objects to get somewhat more accurate positions. Auwers commented that the cluster had not been observed since Messier, and that it was "probably a very loose and poor one."

Camille Flammarion, who from 1917 to 1921 presented a thorough study of the Messier catalogue in the **Bulletin** of the Astronomical Society of France, in the May, 1919, issue expressed essentially the same conclusion, that there is no cluster M47.

The accompanying Harvard photograph of this region of the sky shows many clusters, but none within the circle that marks the approximate position the cluster should occupy, $7^h\ 52^m.5$, $-15°\ 17'$.

WALTER SCOTT HOUSTON

A portion of a Harvard Observatory photograph taken January 31, 1951, exposure 100 minutes. The circle indicates the approximate position M47 should occupy. At the right is the cluster NGC 2422, with 2423 above it, and 2437 (M46) to its left. In the upper left is NGC 2539.

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OCCULTATION PREDICTIONS

March 6-7 **b Scorpii** 4.8, 15:48.1 −25-36.6, 21, Em: **E** 9:43.1 −0.5 −1.6 344; **F** 9:44.8 −1.5 −0.6 309; **H** 9:18.9 −0.9 +0.7 284.

March 6-7 **Pi Scorpii** 3.0, 15:56.0 −25-58.8, 21, Im: **H** 13:11.9 ... ... 39. Em: **H** 13:50.0 ... ... 349.

March 8-9 **X Sagittarii** 4.4 to 5.0, 17:44.6 −27-48.9, 23, Em: **A** 9:57.1 −1.5 0.0 308; **B** 9:55.7 −1.3 0.0 312; **C** 9:50.2 −1.5 +0.2 298; **D** 9:48.1 −1.2 +0.3 304.

March 9-10 **Sigma Sagittarii** 2.1, 18:52.4 −26-21.4, 24, Im: **E** 11:43.6 −1.8 +1.3 65; **F** 11:20.7 −1.6 +1.0 85. Em: **H** 12:01.1 −1.2 +1.3 258.

For standard stations in the United States and Canada, for stars of magnitude 5.0 or brighter, data from the **American Ephemeris** and the **British Nautical Almanac** are given here, as follows: evening-morning date, star name, magnitude, right ascension in hours and minutes, declination in degrees and minutes, moon's age in days, immersion or emersion; standard station designation, UT, **a** and **b** quantities in minutes, position angle on the moon's limb; the same data for each standard station westward.

The **a** and **b** quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude, respectively, enabling computation of fairly accurate times for one's local station (long. **Lo**, lat. **L**) within 200 or 300 miles of a standard station (long. **LoS**, lat. **LS**). Multiply **a** by the difference in longitude (**Lo** — **LoS**), and multiply **b** by the difference in latitude (**L** — **LS**), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Universal time to your standard time.

Longitudes and latitudes of standard stations are:

A	+72°.5,	+42°.5	**E**	+91°.0,	+40°.0
B	+73°.6,	+45°.6	**F**	+98°.0,	+31°.0
C	+77°.1,	+38°.9	**G**	+114°.0,	+50°.9
D	+79°.4,	+43°.7	**H**	+120°.0,	+36°.0
			I	+123°.1,	+49°.5

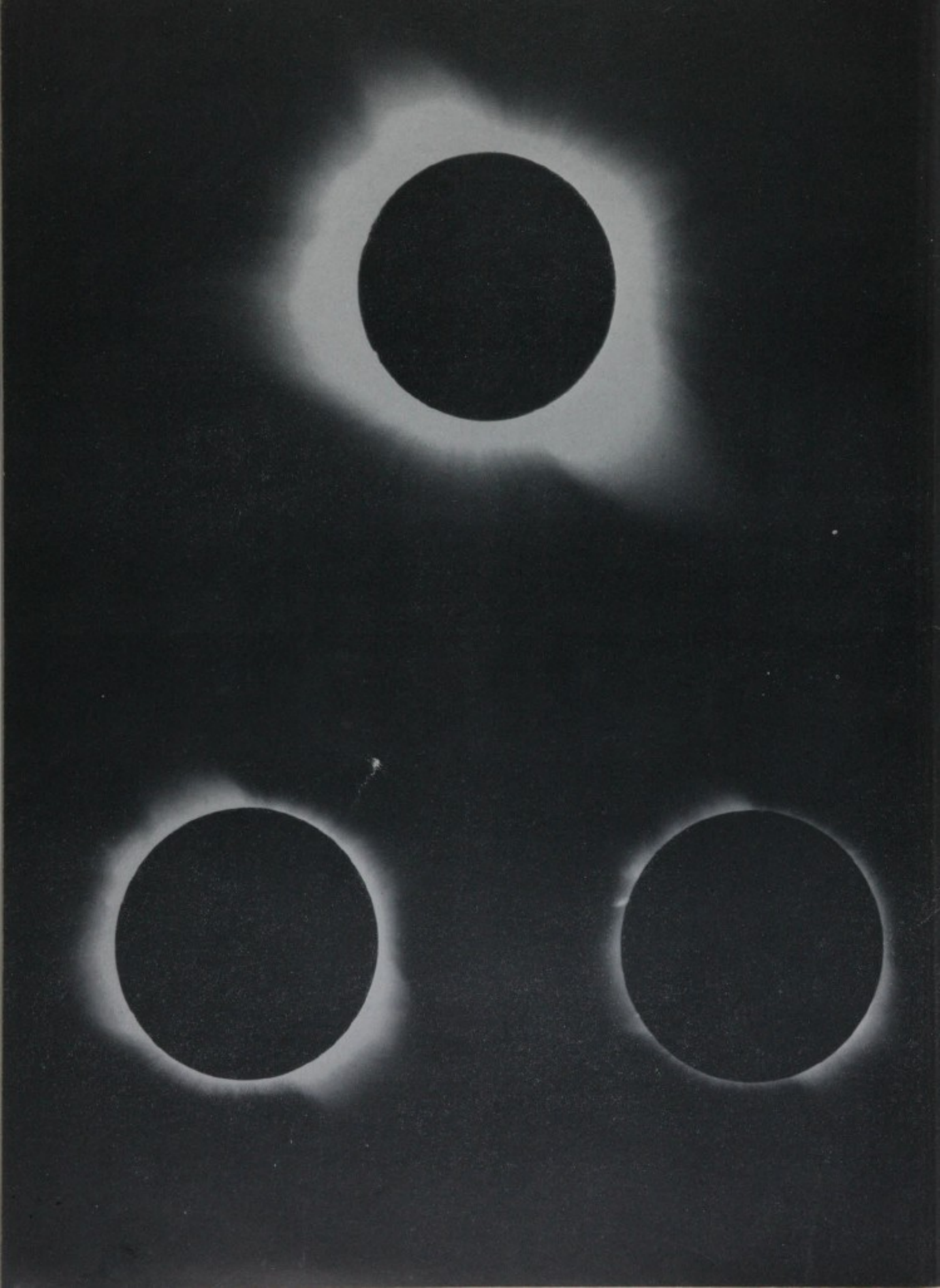
SUNSPOT NUMBERS

December 1, 11, 13; **2**, 17, 12; **3**, 14, 14; **4**, 15, 16; **5**, 29, 22; **6**, 36, 32; **7**, 39, 38; **8**, 51, 50; **9**, 29, 38; **10**, 25, 28; **11**, 33, 34; **12**, 53, 40; **13**, 53, 47; **14**, 65, 63; **15**, 66, 71; **16**, 69, 67; **17**, 68, 67; **18**, 68, 66; **19**, 59, 66; **20**, 45, 50; **21**, 40, 40; **22**, 28, 35; **23**, 25, 35; **24**, 26, 29; **25**, 13, 18; **26**, 19, 36; **27**, 7, 15; **28**, 0, 0; **29**, 3, 7; **30**, 12, 9; **31**, 22, 16. Means for December: 33.5 American; 34.6 Zurich. American mean for 1952, 30.5.

Daily values of the observed mean relative sunspot numbers are given above. The first are the American numbers computed by Neal J. Heines from Solar Division observations; the second are the Zurich Observatory numbers.

UNIVERSAL TIME (UT)

TIMES used on the Observer's Page are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the UT before subtracting, and the result is your standard time on the day preceding the Greenwich date shown.

STARS FOR MARCH

The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of March, respectively; also, at 7 p.m. and 6 p.m. on April 7th and 23rd. For other times, add or subtract ½ hour per week. When facing north, hold "North" at the bottom; turn the chart correspondingly for other directions. The projection (stereographic) shows celestial co-ordinates as circles.